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PHYSICS ABSTRACTS

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SCIENCE ABSTRACTS

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SECTION B, ELECTRICAL ENGINEERING

Edited and Issued Monthly by

THE INSTITUTION OF ELECTRICAL ENGINEERS

In Association with

THE PHYSICAL SOCIETY

THE AMERICAN PHYSICAL SOCIETY

THE AMERICAN
INSTITUTE OF ELECTRICAL ENGINEERS

ABSTRACTS 6673–7443

VOLUME 54 **SEPTEMBER 1951** NUMBER 645

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Amplifiers
Radiocommunication
Mechanical engineering
Illumination
Metallurgy

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 53 (1950) and the Supplement published with the Index to Volume 53 (1950). Reprints of the List of Journals (1950) and the Supplement (1950) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Journals marked * are not received regularly.

**Archit. Rev.*	*Architectural Review.* Architectural Press, 9–13 Queen Anne's Gate, London, S.W.7.
Bol. Radiactividad	*Boletin de Radiactividad.* Instituto Nacional de Geofisica, Rios Rosas 9, Madrid.
Bull. Soc. Chim. France	*Bulletin de la Société Chimique de France.* Ecole Normale Supérieure, 45 rue d'Ulm, Paris, V^{e}.
**Min. Agric. Fish., Lond., Bull.*	*Bulletin of the Ministry of Agriculture and Fisheries.* H.M. Stationery Office, Kingsway, London, W.C.2.
**Publ. Obs. Haute-Provence*	*Publications de l'Observatoire de Haute Provence.* Saint-Michel Observatoire (Basses-Alpes).
Rev. Fis., Rio de Janeiro	*Revista de Física.* Escola Nacional de Engenharia, Largo de São Francisco, Rio de Janeiro.
**Sci. Cult.*	*Science and Culture.* Indian Science News Association, 92 Upper Circular Road, Calcutta.

Notes

Berichte über die Verhandlungen der Sächsischen Akademie der Wissenschaften zu Leipzig. Correction to address: Akademie-Verlag, Schiffbauerdamm 19, Berlin N.W.7.

Journal of the Textile Institute. Change of address: 10 Blackfriars Street, Manchester 3.

Papers in Physical Oceanography and Meteorology. Alteration to address: Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

Spectrochimica Acta. Change of address: The Pergamon Press, 2, 3 and 5 Studio Place, Kinnerton Street, London, S.W.1.

MATHEMATICS 51

517.9 : 530.145.7

6673. Some theorems on perturbation theory. III. E. C. TITCHMARSH. *Proc. Roy. Soc. A*, **207**, 321–8 (*July* 6, 1951).

For Pt II, see Abstr. 6195 (1950). The behaviour of the spectrum of the differential equation $d^2\phi/dx^2 + \{\lambda - q(x) - \varepsilon\sigma(x)\}\phi = 0$ is considered in the case where the unperturbed spectrum is discrete and the perturbed spectrum is continuous. An example is given to show what meaning can be attached to the classical perturbation formula in this case. A.

517.942

6674. Iterative procedures related to relaxation methods for eigenvalue problems. S. H. CRANDALL. *Proc. Roy. Soc. A*, **207**, 416–23 (*July* 6, 1951).

Three iterative procedures for approximating to the solutions of linear eigenvalue problems for systems with a finite number of degrees of freedom are discussed. Two of the procedures are closely related to known iterative procedures while the third is original. The procedures are shown to possess quadratic, geometric and cubic convergence. All three procedures lie within the framework of the relaxation method, each representing a particular manner of fixing the freedom of choice existent in the relaxation method. The study was made to investigate the convergence and behaviour in the large of the relaxation method and to provide guiding principles for the relaxation computer. One particular result of importance is that orthogonalization of trial modes is not essential to the success of the relaxation method. A.

518.5

6675. The California digital computer [Caldic]. P. L. MORTON. *Math. Tables Aids Comput.*, **5**, 57–61 (*April*, 1951).

An outline of the operation of a low-cost machine, designed for simplicity of operation and as an instructional model. Most of the techniques applied are well established. Input and output is by perforated tape; orders consist of 2 decimal digits specifying the operation plus 4 digits usually specifying the location in the memory of the operand. The operation is cyclic, the principal feature being the magnetic drum (memory) with a capacity of 10 000 10-digit numbers with signs, requiring 480 000 memory cells at a surface density of 900 in^{-2} together with 200 specially designed magnetic heads.

A. J. KENNEDY

518.5

6676. Principle and design of a new type Stieltjes integrator. E. H. WINKLER. *Rev. Sci. Instrum.*, **22**, 406–10 (*June*, 1951).

The general application of such an integrator is given. The advantages of the new design are: (*a*) the movement of either tracer does not cause a relative displacement of the other tracer from its curve; (*b*) only rectangular movements are employed; (*c*) the mechanical parts are simple and very sturdy. The accuracy obtainable, as determined by sample integrations, was found to be 0·1% if the curves are followed exactly. A.

518.5 : 621.383 : 621.318.572

6677. An electric analogue computer using the photo cell as a nonlinear element. E. C. KOENIG. *Trans Amer. Inst. Elect. Engrs*, **69** (*Pt II*) 1606–11 (1950).

For abstract see Abstr. 3262 (1951).

519.242.331

6678. Search for periodicities. L. JÁNOSSY. *Acta Phys. Hungarica*, **1** (*No.* 1) 36–55 (1951).

Methods for the search of periodic components contained in a given material are discussed. While the method of Fuhrich is found to be impracticable it is shown that the old method of W. Schmidt, with some small modifications, is an excellent practical method for finding predominant periodic components. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 25

523.16 : 537.591

6679. Cosmic radiation and cosmic magnetic fields. I. Origin and propagation of cosmic rays in our galaxy. A. UNSÖLD. *Phys. Rev.*, **82**, 857–63 (*June* 15, 1951).

The radiofrequency radiation of the galaxy is shown to be analogous not to the "quiet" but to the "disturbed" radiation of the sun (produced by plasma oscillations). Many arguments point towards its origin on stars with an "activity" qualitatively similar to that of the sun but several billion times stronger. It is assumed that in these stars the relation between radiofrequency radiation and the emission of cosmic rays is similar to that observed for the sun by Forbush and Ehmert. In the magnetic field of the galaxy this primary cosmic radiation is "stored" by a factor 10^3 to 10^4, each particle describing a complicated path until it is killed by a nuclear collision, and directional isotropy established. The cut-off of the energy spectrum at small energies, hitherto mostly ascribed to a solar magnetic dipole, is attributed to the stopping power of interstellar matter. Some other theories concerning the origin of cosmic rays are reviewed critically. A.

523.16 : 537.591

6680. Cosmic radiation and cosmic magnetic fields. II. Origin of cosmic magnetic fields. L. BIERMANN AND A. SCHLÜTER. *Phys. Rev.*, **82**, 863–8 (*June* 15, 1951).

The equations governing the behaviour of a wholly or partly ionized gas moving in the presence of a

magnetic field are given. It is emphasized that the electric conductivity is independent of the magnetic field strength in many cases of actual interest. The stationary case of a magnetic field arising from the nonrigid rotation of a gaseous body is considered. Such a field is of the toroidal type. Fields of poloidal type may arise by the contraction of magnetized interstellar matter towards a star. The increase of strength of a magnetic field in turbulent conducting matter (stellar or interstellar) is considered. The conclusion is reached that the turbulence of every order of magnitude leads finally to a magnetic field, the energy density of which corresponds roughly to the energy density of the turbulence considered. If the magnetic field was weak in the beginning, this state was reached at first by the turbulence of smallest scale and smallest velocity, and then by the turbulence of higher orders; hence, the magnetic field strength must change secularly, as long as this process goes on. If our galaxy had only weak fields in its earlier stages, the present magnetic field should correspond to the turbulent velocity associated with distances of the order of 10^3 light years (between 10^{-6} and 10^{-5} gauss), and these fields should be more or less homogeneous over distances of this order. If there were already fields in the beginning, the present fields might be somewhat stronger. A.

523.161

6681. Collision probabilities with the planets and the distribution of interplanetary matter. E. J. Öpik. *Proc. Roy. Irish Acad.*, **54A** (*No.* 12) 165–99 (1951).

Formulae for the probability of collision with a planet of a particle crossing the planet's orbit are derived. The role of perturbations at close encounters is also considered. The ecliptical portions of the zodiacal light may be due chiefly to particles for which $r < 0{\cdot}01$ cm, and $6 < r < 10$ cm. Large particles ($r > 100$ cm) with small eccentricities and inclinations cannot contribute appreciably to the zodiacal light.

D. R. BARBER

523.161

6682. The density of molecules in interstellar space. D. R. Bates and L. Spitzer, Jr. *Astrophys. J.*, **113**, 441–63 (*May*, 1951).

Analysis of Adams' visual estimates indicates that the interstellar lines CH^+ λ4232 and CH λ4300 originate in two types of regions—in the normal obscuring clouds responsible for selective extinction and in circumstellar clouds near stars of late B types. In stars of types O and early B, the intensities of λ4232 and λ4300 are closely correlated with colour excess, E_1; the mean particle densities of these molecules, averaged over the volume in and between the clouds, is about 10^{-8} cm^{-3}. Among stars of later B types, many unreddened stars ($E_1 \leqslant 0{\cdot}05$) show strong molecular lines; the number of molecules per cm^2 in the line of sight averages about 3×10^{12} cm^{-2} for types B2–B5. Of 15 unreddened stars showing the molecular lines, the velocity difference, interstellar minus stellar lines, is positive in all but one case. A theoretical analysis shows that many of the rate coefficients affecting the equilibrium abundance of CH and CH^+ molecules have different values from those assumed hitherto. If best estimates are adopted for all the rate coefficients, the observed molecular densities can be explained only if the clouds are extremely concentrated, with a central density $n_0(H)$ of neutral H about 10^3 cm^{-3}. If, however, the f-value for CH λ4300 is increased by a factor of 30 above the theoretical figure, an increase for which there is some observational evidence, agreement is obtained with $n_0(H)$ equal to about 80. Alternatively, the molecules may be formed at the surface of the grains. The molecules observed in circumstellar clouds may originate from the sublimation of CH_4 from the grains, a process which should occur when the internal temperature of the grains rises much above some 25°K. This hypothesis explains why the circumstellar molecular lines in an unreddened star show a greater radial velocity than do the stellar lines. A.

523.5

6683. The physical theory of meteors. I. A reaction-rate approach to the rate of mass loss in meteors. M. A. Cook, H. Eyring and R. N. Thomas. *Astrophys. J.*, **113**, 475–81 (*May*, 1951).

The generalized reaction-rate theory is applied to the rate of mass loss in meteors. Temperatures around 3 100°K are found for meteor surfaces near the point of maximum luminosity. An additional resistance term arises owing to this mass loss, with a v^3 dependence, which doubles the resistance computed from the usual expression at velocities about 60 km/sec. Some comment on the mechanism of flaring is offered. A.

523.53

6684. On a study of the radiant of the Boötids by the telescopic method and on an attempt to determine the velocity of these meteors by the observation of the hourly drift of the radiant. R. Rigollet. *Ann. Astrophys.*, **14** (*No.* 1) 181–5 (1951) *In French.*

The dependence of the rate of drift of a meteor stream radiant upon the geocentric velocity of the meteors, and the hour-angle and the altitude of the radiant is examined, and a direct graphical comparison of the theoretical drift made with telescopic observations of the Boötid stream. An elliptical orbit of short period is found for this stream.

M. W. OVENDEN

523.66

6685. A comet model. II. Physical relations for comets and meteors. F. L. Whipple. *Astrophys. J.*, **113**, 464–74 (*May*, 1951).

For Pt I see Abstr. 5434 (1950). It was shown in Pt I that the icy conglomerate model for comets explains the anomalous accelerations of certain comets and also possible reductions in the effective attraction by the sun. These effects depend upon a moderate loss of matter, $\Delta M/M$ per period. This loss measures the loss of radius, $\Delta R/R$, while the solar radiation determines the maximum loss of radius by sublimation. By this means an upper limit of radius for 7 comets has been determined. The model predicts a large excess of unobserved hydrides, H_2O, NH_3 and CH_4 molecules, as compared to the observed CO^+, C_2 and CN. For Halley's Comet, using Wurm's calculations for the rate of loss of CO^+ and C_2 and using the total loss of ices calculated from solar radiation for a nucleus of radius 10 km, the relative abundances of CO^+ and C_2 to the combined

hydrides are 10^{-5} and 10^{-3}, respectively. These abundances are roughly consistent with certain of ter Haar's calculations for molecules formed from interstellar atoms. Calculations show that the predicted excess of hydrides will produce no appreciable Rayleigh scattering in comets and also little electron scattering, should all atoms become singly ionized by photo-ionization. Little visible radiation from the hydrides of C, N and O would be expected. The comet model requires that a large cometary nucleus eject visual or photographic meteoroids with greater velocities than a small nucleus at the same perihelion distance (velocity proportional to the square root of the radius). Hence the meteor streams from the greater comets should generally be more dispersed and more uniform from year to year than streams from lesser comets with comparable orbits. A.

523.72

6686. Some characteristics of 10·7-centimetre solar noise. II. A. E. COVINGTON. *J. Roy. Astron. Soc., Can.*, **45**, 49–61 (*March–April*, 1951).

For Pt I see Abstr. 5023 (1951). Describes the properties of bursts of solar noise. M. W. OVENDEN

523.72

6687. The origin of solar energy according to Bethe's theory. J. A. SABATO. *Cienc. y Tecn.*, **116**, 221–8 (*May*, 1951) *In Spanish.*

523.72

6688. A search for He^3 in the sun. J. L. GREENSTEIN. *Astrophys. J.*, **113**, 531–5 (*May*, 1951).

Nuclear processes in the sun might produce an appreciable abundance of the He^3 isotope if the proton-proton reaction ended at He^3. The chromospheric wavelengths, observed at eclipses, and accurate wavelengths of a few lines observed without eclipse or in absorption are compared with the isotope shifts measured at the Argonne National Laboratory. No evidence is found for the existence of He^3. The ratio determined from the shifts and from the absence of certain lines is $He^3/He^4 \simeq 0{\cdot}02 \pm 0{\cdot}03$. A.

523.72

6689. Lithium and the internal circulation of the sun. J. L. GREENSTEIN AND R. S. RICHARDSON. *Astrophys. J.*, **113**, 536–46 (*May*, 1951).

The profiles and intensity of the Li resonance doublet at $\lambda 6708$ have been measured on the solar disk and in the spot penumbra, with dispersion 0·7 Å/mm. A special technique was required, since the lines have a central absorption less than 3%. The isotope ratio Li^6/Li^7 is less than 0·25 and may be the same as on the earth, 0·08. From the equivalent width the abundance of Li has been found to be $6{\cdot}7\times10^9$ atom/g. Two different methods of analysis yield the abundance ratio H/Li as $1{\cdot}4\times10^{11}$ or $0{\cdot}6\times10^{11}$. The ratio Li/Ca is 7×10^{-6}. Compared to the other metals, Li is only one one-hundredth as abundant as on earth. Analysis of the nuclear cross-sections for proton capture shows that in equilibrium with protons the ratio Li^6/Li^7 should be small, in agreement with observation. The lifetime of Li is short at $T > 3\times10^6$ degrees. The deficiency of Li in the sun may arise from a very slow circulation down to at least half the solar radius with period near 7×10^8 years. If the circulation is more rapid, all Li should have been destroyed. Accretion from interstellar matter can maintain the observed Li abundance only if the space density is improbably high. A.

523.72

6690. Temperature gradient in the sun's atmosphere measured at radio frequencies. J. P. HAGEN. *Astrophys. J.*, **113**, 547–66 (*May*, 1951).

The intensity of the radiation from the quiet sun varies with radio wavelength. The purpose of this paper is to discuss this radiation and to show that it may be treated as thermal radiation originating in the corona and chromosphere. New measurements at the short wavelength end of the radio spectrum are reported. An analysis of these measurements in conjunction with measurements of others at longer wavelengths is made, and from the analysis, with the assumption that previously determined values of the electron concentration in the sun's atmosphere are correct, the temperatures of the inner corona and of the chromosphere are determined. It is shown that the temperature is fairly uniform at less than 10 000°K to a height of 10 000 km and then rises steeply to a temperature of 1 000 000°K at a height of 25 000 km. A.

523.72

6691. Distribution of radiation across the solar disk at a frequency of 81·5 Mc/s. K. E. MACHIN. *Nature, Lond.*, **167**, 889–91 (*June* 2, 1951).

A modification of Stanier's method of obtaining the (assumed radially-symmetrical) distribution of equivalent solar temperature [see Abstr. 3705 (1950)] is described, with reference to the correction for sunspot radiation. The observations at 500 Mc/s (Stanier) and 81·5 Mc/s are interpreted in terms of a non-equilibrium temperature distribution in the corona. M. W. OVENDEN

523.72 : 538.566.2

The relativistic theory of electro-magneto-ionic waves. *See Abstr.* 7125

523.72/.75

6692. Source points of radio noise bursts associated with solar flares. M. A. ELLISON. Letter in *Nature, Lond.*, **167**, 941–2 (*June* 9, 1951).

The moving source of a flare radio burst is identified as the plasma oscillation at the head of the surge seen to be ejected by major flares when observed in H-α with the spectrohelioscope. M. W. OVENDEN

523.74

6693. On the apparent effect of the earth on solar activity. J. BOUŠKA. *C.R. Acad. Sci., Paris*, **232**, 1643–5 (*April* 30, 1951) *In French.*

Solar activity data for the years 1935–1949 are analysed for an asymmetry between the east and west hemispheres for the formation and decay of sunspots, the Wolf numbers, solar flares, prominences and the corona. M. W. OVENDEN

523.743

6694. Interpretation of the measurements of radial velocities of the solar granules. C. DE JAGER AND J.-C. PECKER. *C.R. Acad. Sci., Paris*, **232**, 645–7 (*April* 30, 1951) *In French.*

It is pointed out that the Doppler displacements

observed in the spectra of solar granules do not give the actual radial velocity of the granule, as is usually supposed, but a mean of this velocity and the radial velocity (small or possibly zero) in the zone of radiation. Neglect of this factor is shown to lead to an underestimate of the energy transported by the granules by a factor of the order of 5–15.

M. W. OVENDEN

523.743

6695. Equivalent widths of solar lines and microturbulence. J.-C. PECKER AND C. DE JAGER. *C.R. Acad. Sci., Paris*, **232**, 1813–14 (*May* 16, 1951) *In French.*

The radial velocities of very small elements of the solar atmosphere influence the contour of the solar lines rather than their positions. The existence of exterior non-turbulent layers in the solar atmosphere is shown to modify the contours; neglect of this factor leads to an underestimate of the energy of microturbulence by a factor of the order of 80–500 (see also preceding Abstr.). M. W. OVENDEN

523.746

6696. Remarks on the Evershed effect. R. MICHARD. *Ann. Astrophys.*, **14** (*No.* 1) 101–4 (1951) *In French.*

The observational evidence for the variation of the Evershed effect with the position of the sunspot on the disk, its magnetic field and its area is discussed.

M. W. OVENDEN

523.746

6697. Radio emission from the sunspot of central meridian passage 1950 June 14. A. MAXWELL. Letter in *Observatory*, **71**, 72–4 (*April*, 1951).

Strong radio emission on 3·7 m from an otherwise inactive sunspot is reported. The duration of the emission corresponded to a high angular width of 80° for the spot polar diagram, and was asymmetrical about the C.M.P. A correlation between the radio emission and changes in brightness of the bright hydrogen flocculus associated with the spot is suggested. M. W. OVENDEN

523.752

6698. A model of the solar chromosphere in hydrostatic equilibrium. A. KOECKELENBERGH. *Bull. Acad. Roy. Belge Cl. Sci.*, **37** (*No.* 3) 252–9 (1951) *In French.*

Theoretical calculations based on radio-solar measurements within the frequency range 24 000 to 600 Mc/s yield values for chromospheric electron-temperatures which agree closely with those computed on the basis of the equation of hydrostatic equilibrium. The two models are compatible for chromospheric altitudes (and temps.) lying between 500 km (60 000°K) and 7 000 km (600 000°K).

D. R. BARBER

523.755

6699. The intensity variation of the green coronal line, 1943–1950. A. BEHR. *Z. Astrophys.*, **28** (*No.* 3) 296–303 (1951) *In German.*

Observations from Kanzelhöhe, Wendelstein and Zugspitze are discussed with special reference to the problems encountered when comparing observations of the corona made at different observatories.

M. W. OVENDEN

523.77

6700. The solar curve of growth for lines of Cr I. A. R. SANDAGE AND A. J. HILL. *Astrophys. J.*, **113**, 525–30 (*May*, 1951).

Curves of growth for solar Cr I lines have been constructed from laboratory *gf*-values. The displacements of these curves as a function of excitation potential gives an unexpectedly low excitation temperature of 3 790° ± 20°K. The final composite curve of growth agrees well with Wrubel's theoretical curve. A fit to the theoretical curve gives a total velocity of 2·3 km/sec, a turbulent velocity of 1·9 km/sec and a damping factor of $\Gamma/\gamma_{cl} = 12 \cdot 6$. Evidence from Cr I lines whose lower state is of odd parity suggests that the parity effect found in Fe is due to selective pressure broadening. Adopting Estabrook's absolute *f*-values to calibrate Hill's relative scale, 10^{16} Cr I atoms per gram of solar matter are found. Correction for the degree of ionization gives, for the total number of Cr atoms per gram of material, $\log N_t = 17 \cdot 24$. A comparison with Brown's meteoritic abundances is made. A.

523.77 + 523.87 : 535.338.42

6701. Researches on the CH bands in stellar and solar spectra. TCHENG-KIEN. *Ann. Astrophys.*, **14** (*No.* 1) 54–84 (1951) *In French.*

Theoretical intensities in the Raffety and solar G bands are calculated for a temperature of 6 000° and compared with measured values in solar and stellar spectra. The G band shows a strong correlation with spectral type for F to M-type stars, and a slight luminosity correlation in G-type stars only. The Raffety band is probably present in the sun, but the dispersion used for the stars is insufficient to confirm its presence in stellar spectra. D. L. EDWARDS

523.78 : 526.6

6702. Spectrophotometric determinations of contact at total eclipses of the sun. H. KRISTENSON. *Stockholms Obs. Ann.*, **17** (*No.* 1) 97 *pp.* (1951).

A detailed account (with summary of previous and allied investigations) of the flash-spectrum photometry carried out by the Lund observers at the total eclipse in northern Scandinavia, July 9, 1945. Precise spectrophotometry of the rapidly changing solar light at 2nd and 3rd contacts was attempted at two stations, 30 km apart. A knowledge of the topography of the moon's limb at the relevant position angles allowed of an accurate differential timing of the inner contacts as observed from the two stations, to within ±0·028 sec, an error which permits precise geodetic calculations. Under more favourable conditions, i.e. matched optical equipment, placed at sites well separated and lying on the central line of totality, an error of only 0·015 sec appears probable.

D. R. BARBER

523.823 : 523.85

6703. Photoelectric studies. VI. Color-luminosity arrays for stars in Praesepe and in M 39. O. J. EGGEN. *Astrophys. J.*, **113**, 657–62 (*May*, 1951).

For Pt V, see Abstr. 5037 (1951).

523.823 : 523.85

6704. Photoelectric studies. VII. Color and magnitude systems for brighter stars and the color-spectral-type relation. O. J. EGGEN. *Astrophys. J.*, **113**, 663–71 (*May*, 1951).

523.842

6705. The relative equilibrium of heterogeneous fluids in rotation: the problem of double-stars. L. EVRARD. *Ann. Astrophys.*, **14** (*No.* 1) 17–39 (1951) *In French.*

A mathematical study, based on Wavre's method of approximation, of the figure of equilibrium for a 2-body rotating system when the orbital period equals the period of revolution. D. R. BARBER

523.87

6706. Spectrophotometric study of some sub-dwarfs. J. BERGER, R. CANAVAGGIA, D. CHALONGE AND A.-M. FRINGANT. *C.R. Acad. Sci., Paris,* **232,** 2079–80 (*June* 4, 1951) *In French.*

The stars, BD +71°31; +72°94; +17°4708, and −14°6437, whose spectra were photographed with the 82 in McDonald reflector, have been compared with 3 normal stars of similar types, viz. ε Cep.; 78 UMa., and σ^2UMa. Their Balmer discontinuities are markedly smaller than normal for their type, whilst the colour temperatures, derived from blue-violet gradients, are lower than those of normal F stars of corresponding type. D. R. BARBER

523.872 : 523.877

6707. Erratum: Spectrophotometry of the F stars and of the τ Ursae Majoris. I. J. L. GREENSTEIN. Note in *Astrophys. J.*, **113,** 705 (*May*, 1951).

See Abstr. 2681 (1948).

523.873

6708. The equivalent widths of calcium and hydrogen absorption lines in the near infra-red of stellar spectra. H. E. BUTLER. *Proc. Roy. Irish Acad.*, **54 A** (*No.* 6) 87–114 (1951).

Intensities of the Ca triplet at 8 498, 8 542, 8 662 Å, and of the Paschen series P11 to P20, were measured in 80 bright stars well distributed in spectral type and luminosity. Results show a strong luminosity effect in the Ca lines for types F5 to K6. In the Paschen lines there is a similar effect, but for the earlier spectral types it varies down the series, being zero at P14 and reversing sign for those of smaller quantum number. Comparisons are made with the behaviour of the H and K and Balmer lines. D. L. EDWARDS

523.875

6709. A relation between the positions of the white dwarfs on the Russell diagram, their hydrogen content, and their mass. P. COUTEAU. Note in *Ann. Astrophys.*, **14** (*No.* 1) 176–7 (1951) *In French.*

523.877

6710. Contribution to the study of radiative equilibrium (influence of the convective zone). R. CAYREL. *Ann. Astrophys.*, **14** (*No.* 1) 1–16 (1951) *In French.*

Based on Chandrasekhar's approximate solution to the equation of transfer, it is shown that the concept of adiabatic equilibrium in the convection zone of a stellar (white-dwarf) atmosphere is fallacious. The effect of a radiative zone on a convection zone is studied, as also are relations between temperature and flux distribution. D. R. BARBER

523.877

6711. Stellar models with variable composition. II. Sequences of models with energy generation proportional to the fifteenth power of temperature. E. J. ÖPIK. *Proc. Roy. Irish Acad.*, **54 A** (*No.* 4) 49–77 (1951).

Previous computations [Abstr. 6225 (1950)] are extended to cover the temp.-dependence of energy production and the continuous variation of H content throughout the star. Various models computed are used as a basis for a discussion of the variation of luminosity with age; it is suggested that solar luminosity will increase at a gradually accelerated rate. R. A. NEWING

523.877

6712. Transfer of radiation. II. Radiative transfer in absorption lines. D. H. MENZEL AND H. K. SEN. *Astrophys. J.*, **113,** 482–9 (*May*, 1951).

For Pt I, see Abstr. 29 (1950). The equation of the formation of absorption lines in the Milne–Eddington model of a stellar atmosphere has been solved by an extension of the method described in Pt I. The authors assume an expansion of the "source function," $J_\nu(\tau) = \frac{1}{2}(1-\lambda)\int_{-1}^{1} I_\nu(\tau, \mu)d\mu + \lambda(a + b\tau)$, of the form $J(\tau) = a + b\tau + ce^{-m\tau} + \sum_0^\infty A_j K_{j+2}(\tau)$. The equations have been solved for a four-term expansion of $J(\tau)$, and the values of R and r obtained have been tabulated for the standard value of $\lambda = 0{\cdot}2$ and various values of the parameter x, which is a function of the frequency ν. A special feature of the method is that it is not restricted to the atmospheric surface but enables one to evaluate the "source function" $J(\tau)$ for any τ. A.

523.877

6713. Transfer of radiation. III. Reflection effect in eclipsing binaries. D. H. MENZEL AND H. K. SEN. *Astrophys. J.*, **113,** 490–5 (*May*, 1951).

The reflecting star is exposed to a parallel beam of radiation of flux πF per unit area normal to itself and incident at an angle β normal to the boundary of the atmosphere. The emergent intensity corresponding to the solution of 4 simultaneous equations has been calculated. The two sets of values agree to within one part in a thousand, on the average, and somewhat less for $\beta = 0°$, on account of a singularity in the solution. The solution of more equations does not consistently improve the agreement. It is believed that for higher accuracy the trial function for $B(\tau)$ needs to be improved. A.

523.877

6714. The propagation of shock waves in a stellar model with continuous density distribution. P. A. CARRUS, P. A. FOX, F. HAAS AND Z. KOPAL. *Astrophys. J.*, **113,** 496–518 (*May*, 1951).

Aims at investigating the properties of progressing waves which arise if a compressible-gas configuration, in which the density ρ_0 diminishes with increasing distance r from the centre, as $\rho_0 \sim r^{-5/2}$ is disturbed from its state of equilibrium by an instantaneous central explosion. It is shown that, if this explosion has been sufficiently energetic for the outgoing disturbance to possess the characteristics of a shock wave, the central part of the configuration will be

effectively evacuated by the explosion up to a certain distance from the centre, depending on the amount of energy liberated by the initial explosion. If the release has been instantaneous (and, in consequence, the total energy of the wave motion is independent of the time t), the inner boundary of the flow (enclosing the empty core) becomes, by definition, a surface of contact discontinuity. A.

523.877

6715. Erratum: Hydrogen content and energy-productive mechanism of white dwarfs. T. D. LEE. *Astrophys. J.*, **113**, 705 (*May*, 1951).

See Abstr. 6979 (1950).

523.877 : 539.17

6716. On certain nuclear reactions of astrophysical importance. II. Creation of electron pairs. Influence on the formation of neutrons. P. DUMÉZIL-CURIEN. *Ann. Astrophys.*, **14** (*No.* 1) 40–5 (1951) *In French.*

Previous calculations [Abstr. 5475 (1950)] of reaction rates for the formation of neutrons from protons and electrons in a medium of pure H are modified to allow for the formation of electron pairs from γ-radiation in equilibrium with matter. Calculations are made for temperatures 10^9, 5×10^9 and 10^{10} degrees. R. A. NEWING

523.877 : 539.17

6717. On certain nuclear reactions of astrophysical importance. III. Hydrogen suddenly raised to a temperature of several milliard degrees. P. DUMÉZIL-CURIEN AND E. SCHATZMAN. *Ann. Astrophys.*, **14** (*No.* 1) 46–53 (1951) *In French.*

The temp. of a region of a pure H star is assumed to be raised suddenly by the passage of a shock wave. Possible nuclear reactions involving protons and electrons and the products of these reactions are discussed, and reaction velocities are determined. An estimate is made of the energy liberated per g of matter. It is concluded that the nuclear processes considered are not sufficient to maintain the shock wave. R. A. NEWING

523.877 : 551.511

6718. Remarks on the law of rotation in terrestrial and stellar zones of instability. L. BIERMANN. *Z. Astrophys.*, **28** (*No.* 3) 304–9 (1951) *In German.*

A theoretical treatment of conditions existing in thermally-conditioned unstable zones of rotating bodies, e.g. atmospheres of earth and stars. The consequences to dynamical meteorology, and to dynamics of stellar and interstellar material are briefly outlined. D. R. BARBER

PHYSICS 53

53.081

6719. An introduction to the rationalized M.K.S. system of units. G. F. NICHOLSON. *Brit. J. Appl. Phys.*, **2**, 177–82 (*July*, 1951).

It is shown that the rationalized M.K.S. system of units when adopted in presenting the subject of electromagnetism, supplied the need for a single system of units with the least possible disturbance to current practice. The informative natures of the formulae and dimensional expressions arising from the use of the system are stressed and the case for the general adoption of the system in physics is examined. Some units and conversion factors are tabulated. Difficulties arising from the historic development of magnetic units are discussed. A.

FUNDAMENTALS 530.1

530.1

6720. The structure of the system of physical concepts. R. FLEISCHMANN. *Z. Phys.*, **129** (*No.* 4) 377–400 (1951) *In German.*

A distinction is made between "Grossenarten" (i.e. physical properties or concepts such as length, frequency, efficiency, specific heat, etc.), and physical quantities. The "Grossenarten" can be multiplied and divided but not added or subtracted. They form a free Abel group in the mathematical sense. The various relations between the "Grossenarten" occurring in geometry, dynamics, mechanics, electricity, magnetism, gravitation and heat are tabulated and discussed. The properties of the group (basic system), the number of necessary basic elements, the similarity to the elementary cells of a point lattice, the questions of independence and uniqueness and the relation of the basic to the conventional system of dimensions are examined. The factor "c" which occurs in Maxwell's electromagnetic equations in the Gauss c.g.s. system is shown to be a scalar, the "electromagnetic linkage," and not the vector "light velocity." The addition of units and thus the transition from "Grossenarten" to physical quantities is discussed. S. WEINTROUB

530.12

6721. Remarks on the slowing down of time by the effect of a gravitational field. J. BECQUEREL. *C.R. Acad. Sci., Paris*, **232**, 1617–20 (*April* 30, 1951) *In French.*

530.12

6722. Radiation and gravitational equations of motion. L. INFELD AND A. E. SCHEIDEGGER. *Canad. J. Math.*, **3** (*No.* 2) 195–207 (1951).

In an earlier system of successive approximations [Abstr. 4074 (1951)] integrability was ensured by the introduction of suitable dipole terms; it is now shown that integrability at any stage may be expressed entirely as a co-ordinate condition. The influence of co-ordinate transformations upon the form of the equations of motion is discussed, and it is shown that, in the case of gravitational radiation, the radiation terms may always be eliminated by a suitable transformation. It is further shown that it is always possible to set up a co-ordinate system for which the equations of motion of any order have Newtonian form. R. A. NEWING

530.12

6723. On the differential identities of an affinity. E. SCHRÖDINGER. *Proc. Roy. Irish Acad.*, **54A** (*No.* 5) 79–85 (1951).

The identities are established by the variation of a scalar density dependent upon the components and first derivatives of an affine connection.

R. A. NEWING

530.12

6724. Action as a coordinate of space. IV. YU. B. RUMER. *J. Exp. Theor. Phys., USSR*, **21**, 454–61 (*March*, 1951) *In Russian.*

For Pt III see Abstr. 2177 (1950). Sets out to show that 5-optics, being a synthesis of the classical field theories and quantum mechanics, of itself leads to the recognition of the existence of "fundamentons" and thus incorporates the formal apparatus of meson theory with the general frame of unified field theory. No specialization of the 5-space is used, thus no special e/m value chosen for the fundamenton. This means that the formal apparatus of the unif. field theory is the same for gravitation radiation and electromagnetic radiation. Separation of radiation into gravitational and electromagnetic is admissible only so far as "induction from action" is negligible, i.e. while we remain inside the frame of classical approximation. If we choose $e_0/m = c^2\sqrt{(\kappa/2\pi)}$ we obtain the quantum theory of gravitation waves. Yet in quantum theory the electromagnetic component of any gravitational radiation must not be neglected. Only the small value of the charge $e_0 = mc^2\sqrt{(\kappa/2\pi)}$ causes insuperable difficulties to the detection of the radiation of the charge of "neutral" particles by experiment. If we assume the value e/m as for the electron, we arrive at the quantum theory of the electromagnetic waves. But in the quantum theory the radiation of the charge must not be neglected, in other words, account must be taken of the fundamentons. According to the theory presented, these fundamentons become conspicuous in cosmic radiation and in β-disintegration and are mistakenly identified with electrons in the present theories.

B. F. KRAUS

530.12

6725. On gravitational waves. M. BRDICKA. *Proc. Roy. Irish Acad.*, **54A** (*No.* 9) 137–42 (1951).

An exact solution of the field equations is obtained in which energy transport is balanced by a fictitious "negative" wave whose energy-momentum tensor is the negative of that for an electromagnetic plane wave.

R. A. NEWING

530.12

6726. Gravitational transverse-transverse waves. A. E. SCHEIDEGGER. *Phys. Rev.*, **82**, 883–5 (*June* 15, 1951).

It has been stated in earlier papers that no system of masses subject to their gravitational field alone can radiate gravitational waves, if the approximation procedure of Einstein, Infeld, and Hoffman is adopted. However, this result was proved explicitly only for radiation of purely longitudinal and transverse-longitudinal waves. In this paper a new deduction of that fact for the types of waves mentioned above, is given. Furthermore, the case of transverse-transverse waves is extensively investigated, and it is shown explicitly that there cannot be any radiation of such waves either.

A.

530.12

6727. Nonstatic solutions of Einstein's field equations for spheres of fluid radiating energy. P. C. VAIDYA. *Phys. Rev.*, **83**, 10–17 (*July* 1, 1951).

The energy tensor for a mixture of matter and outflowing radiation is derived, and a set of equations following from Einstein's field equations are written down whose solutions would represent nonstatic radiating spherical distributions. A few explicit analytical solutions are obtained, which describe a distribution of matter and outflowing radiation for $r \leqslant a(t)$, an ever-expanding zone of pure radiation for $a(t) \leqslant r \leqslant b(t)$ and empty space beyond $r = b(t)$. Since $db(t)/dt$ is almost equal to 1 and $da(t)/dt$ is negative, the solutions obtained represent contracting distributions, but the contraction is not gravitational because m/r is a constant on the boundary $r = a(t)$, m being the mass. The contraction is a purely relativistic effect, the corresponding Newtonian distributions being equilibrium distributions. It is hoped that the scheme developed here will be useful in working out solutions which would help in a clear understanding of the initial or the final stages of stellar evolution.

A.

530.13 : 530.145

6728. Elimination of arbitrary constants in the relativistic theory of quanta. E. C. G. STUECKELBERG AND T. A. GREEN. *Helv. Phys. Acta*, **24** (*No.* 2) 153–74 (1951) *In French.*

The elimination is effected by a principle, which results in a definite rule for calculating the S-matrix for collisions in a definite space-time region V. By the integral method used throughout, both self-energy and boundary divergences arising from the boundaries of V are eliminated.

G. J. KYNCH

530.145

6729. Relation between the classical equation of a self-coordinated field and the quantum mechanical one. M. A. MOKULSKIĬ. *J. Exp. Theor. Phys., USSR*, **20** 688–92 (*Aug.*, 1950) *In Russian.*

The quantum mechanical equation goes over into the classical one of Vlassov as $h \to 0$.

J. JACOBS

530.145

6730. On the quantum theory of the elementary particles. II. Quantum field dynamics. K. V. ROBERTS. *Proc. Roy. Soc. A*, **207**, 228–51 (*June* 22, 1951).

The quantum field dynamics outlined in Pt I [Abstr. 1604 (1951)] is developed in detail for an arbitrary system of interacting fields. The theory is proved to be covariant, and its formal consistency is made to depend on the integrability conditions given by Dirac. These are discussed in an appendix. It is shown that each system may be described by its Lagrangian, because there is a general order for the operators in the corresponding Hamiltonian function which ensures that the integrability conditions are satisfied. The Dyson S-matrix is expressed in terms

of the interaction Hamiltonian function, but may be evaluated with the help of the interaction Lagrangian. The reason for the appearance of the more complicated interaction Hamiltonian function is explained. A.

530.145

6731. The theory of quantized fields. I. J. SCHWINGER. *Phys. Rev.*, **82**, 914–27 (*June* 15, 1951).

The conventional correspondence basis for quantum dynamics is here replaced by a self-contained quantum dynamical principle from which the equations of motion and the commutation relations can be deduced. The theory is developed in terms of the model supplied by localizable fields. A short review is first presented of the general quantum-mechanical scheme of operators and eigenvectors, in which emphasis is placed on the differential characterization of representatives and transformation functions by means of infinitesimal unitary transformations. The fundamental dynamical principle is stated as a variational equation for the transformation function connecting eigenvectors associated with different spacelike surfaces, which describes the temporal development of the system. The generator of the infinitesimal transformation is the variation of the action integral operator, the spacetime volume integral of the invariant Lagrange function operator. The invariance of the Lagrange function preserves the form of the dynamical principle under co-ordinate transformations, with the exception of those transformations which include a reversal in the positive sense of time, where a separate discussion is necessary. It will be shown in Sec. III that the requirement of invariance under time reflection imposes a restriction upon the operator properties of fields, which is simply the connection between the spin and statistics of particles. For a given dynamical system, changes in the transformation function arise only from alterations of the eigenvectors associated with the two surfaces, as generated by operators constructed from field variables attached to those surfaces. This yields the operator principle of stationary action, from which the equations of motion are obtained. Commutation relations are derived from the generating operator associated with a given surface. In particular, canonical commutation relations are obtained for those field components that are not restricted by equations of constraint. The surface generating operator also leads to generalized Schrödinger equations for the representative of an arbitrary state. Action integral variations which correspond to changing the dynamical system are discussed briefly. A method for constructing the transformation function is described, in a form appropriate to an integral spin field, which involves solving Hamilton–Jacobi equations for ordered operators. In Sec. III the exceptional nature of time reflection is indicated by the remark that the charge and the energy-momentum vector behave as a pseudoscalar and pseudovector respectively, for time reflection transformations. This shows, incidentally, that positive and negative charge must occur symmetrically in a completely covariant theory. The contrast between the pseudo energy-momentum vector and the proper displacement vector then indicates that time reflection cannot be described within the unitary transformation framework. This appears most fundamentally in the basic dynamical principle. It is important to recognize here that the contributions to the Lagrange function of half-integral spin fields behave like pseudoscalars with respect to time reflection. The non-unitary transformation required to represent time reflection is found to be the replacement of a state vector by its dual, or complex conjugate vector, together with the transposition of all operators. The fundamental dynamical principle is then invariant under time reflection if inverting the order of all operators in the Lagrange function leaves an integral spin contribution unaltered, and reverses the sign of a half-integral spin contribution. This implies the essential commutativity, or anti-commutativity, of integral and half-integral field components respectively, which is the connection between spin and statistics. A.

530.145

6732. Quantum statistics of fields. A. E. SCHEIDEGGER AND C. D. MCKAY. *Phys. Rev.*, **83**, 125–31 (*July* 1, 1951).

Gibbs' theory of ensembles of classical mechanical systems has been modified for the application to quantum-mechanical systems by Klein. In this paper, the formalism of the latter author is applied to Hamiltonians of different types of field theories and thus a consistent theory of field thermodynamics is obtained without explicitly referring to the statistical behaviour of particles that are "contained" in the fields. Speaking in terms of particles, the thermodynamics obtained in this way is the same as for a mechanical system where only the temperature is known, but no other conditions such as the number of particles, the total charge, etc. Specifically, the thermodynamic functions of the non-relativistic and relativistic Schrödinger fields, Dirac's electron field, and the electromagnetic field are deduced. The statistics of the non-relativistic fields correspond to ordinary Bose and Fermi statistics of an ensemble of identical particles; the relativistic cases, however, yield new expressions. The thermal equilibrium at low temperatures of the Dirac electron field turns out to be the "vacuum" state as described in the hole theory. Finally, it is also shown that the application of the present formalism to the electromagnetic field leads back to Planck's radiation theory. A.

530.145

6733. Remarks on the non-local electrodynamics. J. RAYSKI. *Proc. Roy. Soc. A*, **206**, 575–83 (*May* 22, 1951).

In order to construct an electrodynamics free of the usual convergence difficulties we abandon the classical infinitesimal approach and assume the *S*-matrix formalism. The *S*-matrix is constructed by means of correspondence arguments in conformity with the ideas of non-localizability and reciprocity. The new *S*-matrix is free of the usual infinities. The main advantage of the new formalism consists in the finiteness of the self-charge terms. The ideas of reciprocity and non-localizability may acquire more importance in meson theories where the convergence difficulties are more serious than in quantum electrodynamics. A.

530.145 : 538.3

6734. The quantum mechanics of the electron. H. T. FLINT AND E. M. WILLIAMSON. *Proc. Roy. Soc. A*, **207**, 380–8 (*July* 6, 1951).

Concerned chiefly with the introduction of a co-ordinate operator in the quantum mechanics of the electron. It differs from other work on the same subject in the derivation of the form of the operator by an analogy with the quantum expression for the angular momentum of the electron. Expressions for velocity and momentum operators are derived, and the relation between them is formally that of the classical theory in the absence of a field of force. An explanation is offered of the significance of the 5th co-ordinate introduced in Kaluza's theory of the gravitational and electromagnetic field and in Klein's adaptation of it. Further, a new aspect of the question of the quantization of space and time is revealed by the use of co-ordinate operators (X_k), for it appears that the interest lies, not in a property of space-time, but in the quantization of localization of a particle. It is by operations upon (X_k) and not upon (x_k) that mechanical quantities are obtained. The momentum (u_k), like (x_k), keeps its usual meaning, but it also is part of an operator (M_k) of wider significance. This is analogous to the case of the angular momentum of the electron where Dirac's introduction of "spin" shows that the orbital angular momentum is a part of a complete angular momentum operator. Finally, in proceeding to a force operator an additional term arises proportional to the derivative of the acceleration with respect to time. This term, which is usually ascribed to the reaction of the field of the electron, occurs here without reference to the self field, and suggests that, in addition to charge and current, a non-Maxwellian quantity must be considered as interacting with the external field. A.

530.145

6735. Errata: Note on the infrared catastrophe. T. KINOSHITA. Letter in *Progr. Theor. Phys.*, **6**, 134 (*Jan.–Feb.*, 1951). See Abstr. 5096 (1951).

530.145

6736. The polarizability of the proton. J. GÉHÉNIAU AND R. SEVRANCKX. *Bull. Acad. Roy. Belge. Cl. Sci.*, **37**, 138–45 (*Feb.*, 1951) *In French.*

It is shown, by Schwinger's technique, that the self-energy of a proton, in interaction with a pseudoscalar meson field, is finite in the presence of a uniform magnetic field when account is taken of mass renormalization. J. R. MADDOX

530.145

6737. The angular dependence of scattering and reaction cross sections. J. M. BLATT AND L. C. BIEDENHARN. Letter in *Phys. Rev.*, **82**, 123 (*April* 1, 1951).

Methods have been found for evaluating the sums of coefficients which arise when the differential cross-sections are averaged over spins. G. J. KYNCH.

530.145

6738. On the creation of electron-positron pairs in the process of collision between particles of spin ½. G. PETIAU. *C.R. Acad. Sci., Paris*, **232**, 1910–12 (*May* 21, 1951) *In French.*

The differential cross-section is calculated in covariant form in the case where the colliding particles differ from each other and from the particles created. R. H. DALITZ

530.145

6739. The angular correlation theorem and the elimination of interference terms. H. A. TOLHOEK AND S. R. DE GROOT. Letter in *Phys. Rev.*, **83**, 189 (*July* 1, 1951).

The interference terms in angular correlation expressions derived from perturbation theory are shown to vanish if the basic intermediate states diagonalize a certain density matrix. If there is an axis of rotational symmetry, suitable intermediate states may be chosen simply, leading to a theorem proved by Lippmann [Abstr. 3719 (1951)]. R. H. DALITZ

530.145

6740. The renormalization method in quantum electrodynamics. F. J. DYSON. *Proc. Roy. Soc. A*, **207**, 395–401 (*July* 6, 1951).

A new technique has been developed for carrying out the renormalization of mass and charge in quantum electrodynamics, which is completely general in that it results not merely in divergence-free solutions for particular problems but in divergence-free equations of motion which are applicable to any problem. Instead of using a power-series expansion in the whole radiation interaction, the new method uses expansions in powers of the h.f. part of the interaction. The convergence of the perturbation theory is thereby much improved. The method promises to be especially useful in applications to meson theory. A.

530.145

6741. Does there exist in M. de Broglie's theory of the spin 1 particle a quantity analogous to the Hertz vector? M. V. S. VRKLJAN. *C.R. Acad. Sci., Paris*, **232**, 1908–9 (*May* 21, 1951) *In French.*

530.145

6742. Nonlinear spinor fields. R. FINKELSTEIN, R. LELEVIER AND M. RUDERMAN. *Phys. Rev.*, **83**, 326–32 (*July* 15, 1951).

A non-linear spinor field, suggested by the symmetric coupling between nucleons, muons and leptons, has been investigated in the classical approximation. Solutions of the field equations having simple angular and temporal dependence were obtained, subject to the boundary conditions that the fields be regular and that all observable integrals be finite. These boundary conditions lead to a non-linear eigenvalue problem, whose solutions may be systematically discussed in the phase plane. Numerical solutions were obtained with a differential analyser. If charge and mass of the particle-like solutions are defined in terms of $\int s_4 dx$ and $\int T_{44} dx$, then the number of masses corresponding to the same charge turns out to be small in all cases investigated. For certain Lagrangians the non-linearity leads to solutions having positive energy only. The mass ratio between the lightest stable particle and the heaviest unstable particle can be taken of the order of 10^{-3}, if the non-linear coupling constant is properly chosen. Although the specific model is too simple to meet certain obvious requirements, a theory of this general type has some interesting features. A.

530.145

6743. A note on the numerical calculation of asymptotic phases with a numerical study of Hulthén's variational principle. P.-O. LÖWDIN AND A. SJÖLANDER. *Ark. Fys.*, **3**, *Paper* 11, 155–66 (1951).

An improved method for the calculation of asymptotic phases in quantum mechanical scattering problems is developed. The method is based on the numerical integration of the radial wave equation by using a new modification of Gauss's central difference formula. Applications are made to the computation of some *S*-phases connected with the Yukawa potential, and a comparison with the results obtained by Hulthén according to his variational principle shows that his simplified modification of this principle gives phase values which are extremely accurate even when only a few variational parameters are used. A.

530.145

6744. On the theory of strong coupling between nucleons and pseudovector mesons. K. RÜDENBERG. *Helv. Phys. Acta*, **24** (*No.* 2) 89–126 (1951) *In German.*

Detailed development of a charge-symmetric pseudovector meson theory in the strong coupling case, and a comparison of the results with those obtained in weak coupling. A calculation of "nucleon-isobar" energies and the states of complex nucleons. The meson potential differs from that calculated by weak coupling by the numerical factor 1/9.

J. R. MADDOX

530.145

6745. On tensor forces and saturation requirements. H. KANAZAWA. *Progr. Theor. Phys.*, **6**, 126–30 (*Jan.–Feb.*, 1951).

The effects which the tensor forces exert upon the saturation properties of heavy nuclei have not yet been fully investigated. According to Volkoff, the occurrence of large tensor forces in the expression of the interaction of a pair of nucleons tends to favour collapsed configurations of a heavy nucleus and so such theories as involve an extreme predominance of the tensor forces are to be excluded, but about intermediate cases like the Rarita–Schwinger theory one cannot say whether they satisfy the saturation conditions. Experiments concerning two-nucleon systems have been developed recently and the nuclear potentials which harmonize with these experimental results have been introduced. It may be of interest to consider whether these potentials are not contradictory with the saturation properties of heavy nuclei. The saturation properties of heavy nuclei and the saturation requirements to be fulfilled by the nuclear potentials involving tensor forces with the use of the individual nuclear model are formulated. A.

530.145

6746. Interaction of mesons with nuclei. S. HAYAKAWA. *Phys. Rev.*, **82**, 836–9 (*June* 15, 1951).

The interaction of slow π-mesons with nuclei is treated phenomenologically. A nucleus is assumed to be a continuum with potential with respect to a meson. The potential consists of real and imaginary parts, corresponding to the polarization caused by a meson and the absorption of a meson, respectively. The scattering, the absorption, and the production of mesons are qualitatively discussed by analogy with the current theory of nuclear reactions. The difference from the theory based on the weak interaction of mesons with nucleons is presented. A.

530.14

6747. On the scattering of a particle by a static potential. R. JOST AND A. PAIS. *Phys. Rev.*, **82**, 840–51 (*June* 15, 1951).

The behaviour of the solutions of scattering integral equations is studied as a function of the potential strength λ. From an analysis of the second Born approximation for a Yukawa potential it seems indicated that the Born expansion for a nuclear potential has no useful domain of applicability. The convergence of the Born expansion is discussed. It is shown that the Fredholm theory of integral equations enables one to express the solutions as a quotient of infinite power series in λ which still converge when the Born expansion breaks down. Only in exceptional cases can this method be used for obtaining rapid numerical estimates. A.

530.14

6748. The analysis of π-meson production in nucleon-nucleon collisions. K. M. WATSON AND K. A. BRUECKNER. *Phys. Rev.*, **83**, 1–9 (*July* 1, 1951).

A phenomenological analysis of meson production in nucleon-nucleon collisions is proposed. On the basis of an hypothesis that the production takes place for collisions whose impact parameters tend to be less than the range of nuclear forces, a partial wave analysis of the scattering matrix is given. The theory seems capable of describing the experimental results in a simple manner. It is shown, on the assumption that the π-meson is pseudoscalar, that angular momentum and parity considerations play an important role in interpreting the experimental results. If processes involving mesons are related to nuclear forces, then the hypothesis of charge symmetry in nuclear phenomena should receive a crucial test in experiments concerning meson production. A.

530.14

6749. On the connection of the scattering and derivative matrices with causality. W. SCHÜTZER AND J. TIOMNO. *Phys. Rev.*, **83**, 249–51 (*July* 15 1951).

The connection between the *S* matrix and causality suggested by Kronig is analysed; the condition of causality implies that the poles of the analytical functions $S(k)$ are either on the imaginary axis or in the lower half-plane. The possibility of a close connection between the properties of the derivative *R* matrix and causality is also analysed. Although all the properties of the *R* matrix could not be deduced from the requirements of causality, it is considered as an encouraging preliminary result that: (1) The referred distribution of the poles of $S(k)$ can be obtained from the properties of the *R* matrix. (2) These properties of the corresponding *R* matrix are unchanged under a transformation $S(k) \to e^{ik\lambda}S(k)$, with λ positive, which preserves the causal nature of the theory. A.

530.145

6750. Coherent scattering processes arising from quantum correlations. L. GOLDSTEIN. *Phys. Rev.*, **83**, 289–98 (*July* 15, 1951).

Quantum statistical forces in ideal symmetric and antisymmetric fluids establish an ordered arrangement of their fluid molecules in space. The coherent scattering properties of these fluids resulting from this spatial order are studied in this paper. A.

530.145 : 539.152.1

Electromagnetic properties of nuclei and nuclear structure. *See Abstr.* 7179

530.145 : 539.17

6751. A variational approach to nuclear reactions. J. L. JACKSON. *Phys. Rev.*, **83**, 301–4 (*July* 15, 1951).

The formalism of Wigner and Eisenbud for nuclear reactions is carried out by means of a variation principle. A variation principle of the Hulthén type is derived for the R matrix and applied to trial wave functions written in terms of the resonance functions, X_λ, of the Wigner–Eisenbud formalism. As a result, a finite level formula for the R matrix is directly obtained. A.

530.145

6752. Note on the eigenvalue problem in the quantum field theory. K. NISHIJIMA. *Progr. Theor. Phys.*, **6**, 37–47 (*Jan.–Feb.*, 1951).

In some respects, the use of S-matrix in the eigenvalue problem seems to be inadequate, since the truly conserved quantity should be the total energy, including the potential (or interaction) energy, but not the mere kinetic energy. This fact seems to show that the total energy is not an adiabatic invariant, and the concept of "remote past or future" should not be used in the eigenvalue problem. Formulation of the problem, and the qualitative nature of the eigenvalues, are discussed. A.

530.145

6753. The solution of the Schrödinger equation for an approximate atomic field. E. H. KERNER. *Phys. Rev.*, **83**, 71–5 (*July* 1, 1951).

An approximate atomic potential having an "effective nuclear charge for potential," that is, bilinear in the radial distance from the nucleus, is discussed and shown to approximate reasonably well to Hartree or Fermi–Thomas potentials. The Schrödinger equation with the approximate potential is solved as a series of hydrogenic wave functions and as a power series in $Ar/(1 + Ar)$ (A being a parameter of the potential). Some illustrative numerical results pertaining to the Hg atom are presented. A.

530.145.6

6754. Tensor identities in wave-tensor calculus. C. W. KILMISTER. *Proc. Roy. Soc. A*, **207**, 402–15 (*July* 6, 1951).

The quaternion methods of a previous paper [Abstr. 1508 (1950)] are used to formulate clearly the problem of Eddington's "tensor identities" in both single and double frames. As examples, the single-frame theory is used to calculate the well-known gyromagnetic ratio of the electron, and the double-frame to deduce a complete set of equations, of which Eddington has given a few, which include equations having the form of the field equations of general relativity. A discrepancy with Eddington's results is noted, and reasons given for preferring the present equations. A.

530.145.6 : 530.162 : 536.7

6755. The second principle of thermodynamics and wave mechanics. R. JANCEL. *Rev. Sci., Paris*, **88**, 160–77 (*July–Sept.*, 1950) *In French.*

An attempt is made to reduce the requirements demanded if the principle is established using kinetic theory based on quantum mechanics. This involves a critical examination of earlier statements [Abstr. 1130, 2411 (1947)] and their relation to one another.

G. J. KYNCH

530.162

6756. A quantized form of the Boltzmann–Maxwell distribution law. F. GUTMANN AND L. M. SIMMONS. Letter in *Aust. J. Sci.*, **13**, 109–10 (*Feb.*, 1951).

The suggestion is made that the interaction between Maxwell–Boltzmann particles can be taken into account by replacing the temperature T which occurs in the distribution law by $T' = T + C$. The nature of C is discussed for Einstein oscillators. P. T. LANDSBERG

530.162

6757. A generalization of the idea of valuation for given lattices and its application to the distributions of quantum statistics. M.-P. SCHÜTZENBERGER. *C.R. Acad. Sci., Paris*, **232**, 1805–7 (*May* 16, 1951).

[530.162 : 530.145 : 532.7

6758. The quantum mechanics of assemblies of interacting particles. H. S. GREEN. *J. Chem. Phys.*, **19**, 955–62 (*July*, 1951).

The quantum mechanics of fluids at moderately high and very low temperatures is investigated by the extension of a method due to Wigner. The fundamental equation satisfied by the phase space distribution function is solved, on the basis of classical statistics, by two different methods, and quantum corrections for thermodynamical equilibrium are obtained. It is shown that the effective molecular interaction becomes very weak near absolute zero. An estimate is made of the zero-point energy. Corrections due to quantum statistics are obtained. A.

530.162 : 537.3

6759. Irreversibility and generalized noise. H. B. CALLEN AND T. A. WELTON. *Phys. Rev.*, **83**, 34–40 (*July* 1, 1951).

A relation is obtained between the generalized resistance and the fluctuations of the generalized forces in linear dissipative systems. This relation forms the extension of the Nyquist relation for the voltage fluctuations in electrical impedances. The general formalism is illustrated by applications to several particular types of systems, including Brownian motion, electric field fluctuations in the vacuum, and pressure fluctuations in a gas. A.

530.162 : 538.114 : 539.22

6760. Order-disorder statistics. III. The antiferromagnetic and order-disorder transitions. J. E. BROOKS AND C. DOMB. *Proc. Roy. Soc. A*, **207**, 343–58 (*July* 6, 1951).

The method of the previous paper [Abstr. 2929 (1950)] is applied to a 2-dimensional model of an antiferromagnetic. An alternative notation is developed, and this shows that in the absence of a

magnetic field the antiferromagnetic is effectively identical with the ferromagnetic, a result first demonstrated by Kramers and Wannier (1941). In the presence of a magnetic field a number of terms of a series expansion are obtained, and these are used in conjunction with the corresponding high-temperature ferromagnetic expansions to derive a number of qualitative features of an antiferromagnetic. High- and low-temperature series for the magnetic susceptibility in zero field are deduced, and the results are compared with standard approximations. The theory of order-disorder transitions with constituent ratios differing from unity is discussed, and it is shown that for concentrations of one constituent less than 0·226 no long-range order can exist, and there is no singularity. The application of the results to adsorption theory is discussed. The method of Ashkin and Lamb (1943) is generalized to derive a series for long-range order when the constituent ratio differs from unity. A.

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.39 : 518.3

6761. A nomogram for the calculation of relative centrifugal force. V. P. Dole and G. C. Cotzias. *Science*, **113**, 552–3 (*May* 11, 1951).

The nomogram is of orthodox design, and gives the values of centrifugal-force/g for radii between 3 and 30 cm, and for rotational speeds between 500 and 50 000 r.p.m. N. CORCORAN

531.55

6762. The perturbation calculus in missile ballistics. R. Drenick. *J. Franklin Inst.*, **251**, 423–36 (*April*, 1951).

The calculus of perturbations, as used in exterior ballistics, is modified to investigate the effect of disturbing forces upon a rocket trajectory. Its use in establishing principles of guidance and control is demonstrated by two examples—the theory of range control in the V2 missile, and a theoretical system of free-flight guidance by radio. A. C. CLARKE

531.55

6763. Orbital rockets. I. Some preliminary considerations. K. W. Gatland. **II. The rocket structure with special reference to expendable construction.** A. E. Dixon. **III. Conception of an instrument-carrying orbital rocket.** A. M. Kunesch. *J. Brit. Interplan. Soc.*, **10**, 97–123 (*May*, 1951).

A symposium on general design problems and rocket structure, with particular reference to expendable tank construction. A conception of a three-step instrument-carrying rocket to place a 350-pound payload in a 500-mile altitude orbit, using oxygen and hydrazine as propellants, is discussed in detail. A. C. CLARKE

531.571

6764. Combustion in the rocket motor. A. D. Baxter. *J. Brit. Interplan. Soc.*, **10**, 123–38 (*May*, 1951).

The history of a droplet of fuel, during its passage from injector to exhaust in a liquid bipropellant motor, is described. Injection, atomization, ignition and the physical processes during combustion are discussed. A. C. CLARKE

MECHANICAL MEASUREMENTS 531.7

531.714.

6765. A micro-inch micrometer of one-tenth inch range. E. B. Baker. *Rev. Sci. Instrum.*, **22**, 373– (*June*, 1951).

Many instruments exist which will magnify small displacements to almost any degree desired but always at the expense of range. The micrometer screw is a notable exception, but does not give an electrical output nor will it measure distance directly and continuously without extra equipment. The present device combines a lever, a micrometer screw, a sensing element and a servomotor to achieve this purpose. A.

531.714.7 : 621.317.39.082.74

6766. Measurement of displacement and force with inductive pick-ups. F. Stejskal. *Arch. tech. Messen Issue No.* 183 (*Ref. J*86–2) *T*44–*T*45 (*April*, 1951) *In German.*

See also Abstr. 5542 (1950). For the measurement of large displacements the method of Ratzke is described in detail. Here two coils, appropriately mounted on a common core, suffer a change in inductance which can be measured on an a.c. bridge connected to a magic-eye detector. The modifications desirable when measuring creep are shown. The calibration is strictly linear over the range $\pm$ 10 μm but the range $\pm$ 100 μm is still useful. The bridge supply frequency is 500 c/s and vibrations up to 30 c/s can be measured quite accurately. For more rapid oscillations, several arrangements are mentioned and those due to Schmidt and Klein and to Felgner described in detail. The former, though of reduced sensitivity, has low zero-drift. The latter employs two coils with an air-gap between them of up to 5 mm. A carrier frequency of 5 kc/s is used and detection is by means of a modulator bridge. Here the range of linear operation is $\pm$ 100 μm. Also described are the methods of Kleissl (2 kc/s carrier, 24 V battery use) and de Vries (seismograph principles). Force measurements may use the above devices when built into test-pieces or special constructions such as that of Kerris. Here the transmitted force distorts the magnetic path of a coil assembly and resulting changes are detected in a conventional manner. The fixing of all these transducers and their calibration is also described. S. C. DUNN (R)

531.719.1

6767. An instrument for automatically recording waviness of surfaces. C. W. Medhurst. *J. Sci. Instrum.*, **28**, 211–14 (*July*, 1951).

The instrument is of robust construction suitable for everyday production tests on surfaces and yet is of such form that it will not harm the surfaces. Its outstanding feature is that it charts the waviness of

surfaces in only 5% of the time it takes when using a simple Ames dial instrument. A.

531.751.1 : 535.417

Two interferometric techniques. *See Abstr.* 6896

MECHANICS OF FLUIDS 532

532.123 : 536.423.15

6768. The limiting negative pressure of acetic acid, benzene, aniline, carbon tetrachloride, and chloroform. L. J. BRIGGS. *J. Chem. Phys.*, **19**, 970–2 (*July*, 1951).

The limiting negative pressure of acetic acid, benzene, aniline, carbon tetrachloride and chloroform has been measured in relation to temperature. A centrifugal method was employed. The maximum values observed were: CH_3COOH, −288 bars; C_6H_6, −150 bars; $C_6H_5NH_2$, −300 bars; CCl_4, −276 bars; $CHCl_3$, −317 bars. Excepting benzene, the limiting negative pressure of these liquids has not heretofore been measured. All except benzene equal or exceed that of water (−275 bars). Acetic acid, benzene and aniline show a decrease in the limiting negative pressure as the freezing point is approached, like water, but the effect is much less marked. The higher values observed for the polar liquids in comparison with their nonpolar relatives suggests that the dipoles are contributing markedly to the cohesion of the liquid. An investigation of the *cis-* and *trans-* forms of the same liquid is now under way. A.

532.133

6769. The viscosity of suspensions of spheres. II. The effect of sphere diameter. J. V. ROBINSON. *J. Phys. Coll. Chem.*, **55**, 455–64 (*March*, 1951).

For Pt I see Abstr. 2214 (1950). The effect of size is investigated using the methods of previous part. The effective volume of spheres in sugar solution is greater than in water, the difference increases with decreasing sphere diameter. Confirmation is obtained by direct measurement of sedimentation volume.

J. E. CAFFYN

532.137

6770. Contribution to the study of the oil layer. J. HUETZ. *C.R. Acad. Sci., Paris*, **232**, 1906–8 (*May* 21, 1951) *In French.*

Results are quoted for two modifications to a pressure viscometer previously described [*C.R. Acad. Sci., Paris*, **227**, 956 (1948)]. Theory and experiment still agree for the thinnest layer of oil when the two cylinders are made non-concentric. Flow lines are indicated by a method already described [*Thèse, Paris* (1950)], and theory and experiment agree in the delineation of the return flows. The formation and decay of gas bubbles is briefly considered and finally the velocity field is mapped by using coloured particles or threads. E. H. DOCK

532.52

6771. Correlation of space and time in homogeneous turbulence. J. BASS. *C.R. Acad. Sci., Paris*, **232**, 1905–6 (*May* 21, 1951) *In French.*

Conditions in a turbulent fluid are considered with reference to a fixed set of axes and equations are deduced in terms of the mean velocity, the velocity of agitation, and the pressure. The final equation, in terms of series, expresses the relation between two orthogonal four-dimensional vectors. It is shown that turbulence is homogeneous in space and time only for very small intervals, and this is borne out by experiment. At low Reynolds numbers one can assume a tendency to isotropy which is continuous in time. E. H. DOCK

532.525 : 536.7 : 541.124

6772. Thermodynamics and chemical kinetics of one-dimensional nonviscous flow through a Laval nozzle. S. S. PENNER. *J. Chem. Phys.*, **19**, 877–81 (*July*, 1951).

Explicit relations have been obtained for the enthalpy changes in one-dimensional nonviscous flow through a Laval nozzle, where arbitrary deviations from thermodynamic equilibrium of chemical composition and of internal electronic, vibrational, or rotational energy states may occur. These relations are of interest in connection with calculations on the effect of deviations from equilibrium on performance of jet engines. Starting with the equation of continuity for a multicomponent mixture of reacting gases, criteria for near-equilibrium and for near-frozen flow with respect to chemical reactions are derived. The near-equilibrium criteria agree with results obtained previously. The near-frozen flow criteria are new and have not yet been applied to the study of chemical reactions during nozzle flow. A.

532.582.6

6773. Approximation of axisymmetric body forms for specified pressure distributions. J. S. MCNOWN AND E.-Y. HSU. *J. Appl. Phys.*, **22**, 864–8 (*July*, 1951).

The complex relationship between body profile and pressure distribution is important in the design of high-speed undersea bodies. For slender axisymmetric bodies integration of the equations for irrotational flow has been accomplished, the co-ordinates of the body profile being related to the pressure distribution through coefficients of Legendre polynomials. The limitations and applications of this approximate analysis have been demonstrated through comparisons with preassigned conditions and with the results of experiments. Computed values closely approach those preassigned or measured throughout the central portion of the body if the maximum diameter does not exceed three-tenths of the length. The analysis is accordingly useful in designing bodies with low coefficients of drag and low incipient cavitation numbers. A.

532.59 : 538.69

6774. The invariant theory of isotropic turbulence in magneto-hydrodynamics. II. S. CHANDRASEKHAR. *Proc. Roy. Soc. A*, **207**, 301–6 (*July* 6, 1951).

Pt I, Abstr. 1646 (1951). In this paper the invariant theory of isotropic turbulence in magneto-hydrodynamics developed by the writer in a recent paper is extended to include the correlations $\overline{Pu_i'u_j'}$ and $\overline{Ph_i'h_j'}$, of the total pressure, $P(=p+\frac{1}{2}\rho|\mathbf{h}|^2)$, with two components either of the velocity, (u_i), or of the

magnetic field, (h_i). It is shown how the scalars defining these tensors can be expressed in terms of the scalars defining the second-order correlations $\overline{u_i u_j}$, $\overline{u_i h_j}$ and $\overline{h_i h_j}$ if the fourth-order correlations of two components of velocity (respectively, magnetic field) at one point, with two components of velocity or magnetic field at another point, can be assumed to be related to the second-order correlations in the same manner as if they were jointly, normally, distributed.

A.

532.593

6775. The effect of a floating mat on water waves. A. S. PETERS. *Commun. Pure Appl. Math.*, **3**, 319–54 (*Dec.*, 1950).

A mathematical analysis of wave motion in the plane surface of a liquid of great depth, when a half plane in the surface is covered by a floating thin mat. The more general case when the mat boundary is an inclined, instead of a horizontal, plane is also treated. J. G. OLDROYD

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

6776. On virial coefficients and the Born–Green theory of fluids. G. S. RUSHBROOKE AND H. I. SCOINS. *Phil. Mag.*, **42**, 582–93 (*June*, 1951).

The validity of the superposition approximation used in the Born–Green theory of classical fluids is examined by obtaining a virial expansion of the pressure in powers of the density. It is found that the 2nd and 3rd virial coefficients are given correctly, but that the 4th is not. The discrepancy is illustrated numerically by considering explicitly the case of a gas of rigid spheres. The corresponding equations for a two-component mixture are also considered and it is shown that the equations are mutually consistent only when linearized. A.

532.7 : 530.145 : 530.162

The quantum mechanics of assemblies of interacting particles. *See Abstr.* 6758

MECHANICS OF GASES 533

533.12 : 531.758

6777. The densities and limiting densities of vapours. F. L. CASADO, D. S. MASSIE AND R. WHYTLAW-GRAY. *Proc. Roy. Soc. A*, **207**, 483–95 (*July* 23, 1951).

By means of a new type of microbalance working in conjunction with a multiple-point manometer, an accurate comparison of the balancing pressures at the same density of O_2 and benzene vapour has been made at 22°c and in the region of from 19 to 69 mm of benzene pressure. Four samples of highly purified benzene from different sources all gave for the molecular weight of the vapour the same result, which was very close to the theoretical value calculated from International Atomic Weights. It is claimed that the method is of general applicability, and that it is no possible to obtain for vapours at low pressur compressibilities and densities of high accuracy.

533.15 : 532.65 : 551.57

6778. The boundary conditions at a mist-wat interface. P. M. DAVIDSON. *Brit. J. Appl. Phys.*, 193–5 (*July*, 1951).

The boundary conditions are formulated math matically for two extreme cases, which may described as the case of high turbulence and sma droplets and the case of low turbulence and lar droplets. The type of experiment needed to gi a more precise significance to these descriptions indicated.

533.15 : 532.65 : 551.57

6779. Experiments on the boundary conditions at mist-water interface. D. J. EVANS. *Brit. J. App Phys.*, **2**, 196–9 (*July*, 1951).

Experiments with mist-laden air passing dow vertical pipes have been performed with the intentio of testing the theory reported in the preceding Abs It is important to investigate whether the formul derived for the two extreme cases, between which a cases should lie, do in fact arise under practic conditions. The experiments here described we carried out over a wide range of physical conditio (of temperature, water content, and wind velocity and it was found that the formulae for the first ca held over a large range; with diminishing turbulen the results tended towards, and finally attained, t formulae for the second.

533.15 : 539.155

6780. Effect of turbulence in thermal diffusi columns. J. DONALDSON AND W. W. WATSO *Phys. Rev.*, **82**, 909–13 (*June* 15, 1951).

A certain amount of controlled turbulence improv markedly the separation factor and transport thermal diffusion isotope separation column Measurements on this effect are reported for hot-wi columns 3 m long, operating on A gas, and with pow input about 725 W. At pressures 3× that for ons of general turbulence the separation factor q_e is st 1·5. Spacers made of pairs of cross-wires of 40 Ni wire attached to the hot wire every 10 cm along length raise the separation factor q_e for optimu pressure from 9·1 to 27·2. If these spacers a attached every 5 cm, q_e rises further to 36. T optimum pressure increases from 0·17 atmos (spacers) to 0·28 atmos. Identical operation of similar column with a plain hot wire but with slig constrictions every 15 cm in the cold wall giv $q_e = 26·6$. Introduction of these regularly spac interruptions to the lamellar convective flow of t gas also increases the transport of the A^{36} isotope the top of the column. Some analysis of these effe is given.

533.42 : 551.508.

6781. Thermal correction to the cistern and fix scales of the barometer. R. SNEYERS. *Inst. Roy. M Belge Misc.*, *No.* 37, 16 *pp.* (1951) *In French.*

A historical review is given of the various corre tions used in different types of barometers. Fro rigorous theory a general formula is derived, but f

practical use successive simplifications are applied and corresponding approximations are established for the barometers used at Brussels and Uccle. The final formula is analogous to that recommended by the O.M.I. provisional guide and corrected according to the decisions of the 1947 Toronto session of the Commission of Instruments and Methods of Observation. Comments are made on the use of the formula and the accuracy of the measurements it permits. Reasons are given for the choice of 25°C and the height of 750 mm for calculation of errors. R. S. READ

533.45 : 551.508.43

6782. A new measuring and recording instrument for microbarometric investigations, in particular height measurements. A. GRAF. *Z. angew. Phys.*, **3**, 107–10 (*March–April*, 1951) *In German.*

The portable instrument consists of a Bourdon spiral the extension of which is optically magnified and observed in a measuring eyepiece. The spiral is attached to a torsion head and the system is damped. The arrangement is shown schematically. The sensitivity is 0·01 mm Hg and curves of comparison tests with other instruments are given. No description is given of the recording mechanism, but it is stated that it may be made recording by photoelectric means. S. WEINTROUB

533.5

6783. Cold trap anti-icing shield. J. E. SKVARLA AND E. C. EVANS. *Rev. Sci. Instrum.*, **22**, 341–2 (*May*, 1951).

Ice formation from atmospheric moisture on vacuum flasks using liquid N as coolant could be overcome by sealing an Al cap to the flask through which the evaporating coolant gas can flow rapidly and prevent inward diffusion of atmospheric moisture. On the outside of the shield condensed moisture runs off as water. 2 figures. G. WITTENBERG

533.5

6784. A high speed hot baffle for oil diffusion pump systems. R. L. LONGINI. *Rev. Sci. Instrum.*, **22**, 345–6 (*May*, 1951).

A new hot surface baffle is described which reduces the amount of oil vapour in a high vacuum system. Oil molecules striking the hot surface (650°C) are decomposed into permanent gases and non-volatile C, of which the total pressure is less than 10^{-9} mm. Constriction between the baffle and the evacuated system ensures that molecules which escaped decomposition are returned to the baffle. 1 figure. G. WITTENBERG

533.5

6785. Glass-to-metal seal for vacuum systems. F. P. STROTHER AND H. GRANBERRY. Note in *Rev. Sci. Instrum.*, **22**, 341 (*June*, 1951).

533.583 : 621.385.032.46

6786. Efficiency and mechanism of barium getters at low pressures. S. WAGENER. *Brit. J. Appl. Phys.*, **2**, 132–8 (*May*, 1951).

The gettering rates of Ba getters for O_2, N_2, H_2, CO, CO_2 and water vapour were measured in the pressure range between 5×10^{-8} and 5×10^{-5} mm Hg. Values for the decay in gettering rate during use of the getter are given. The gettering effect at these low pressures is almost entirely due to the take-up of atoms or metastable molecules produced by the impact of electrons on the stable gas molecules. Ions play a negligibly small part in the gettering process The position of the getter with respect to the electronic discharge influences the getter efficiency due to two causes: re-formation of stable molecules and flow resistance between discharge and getter. Examples for the two effects which affect different gases in different ways are given. A.

533.6.011.311

6787. Motion in the wake of a thin plate at zero incidence. D. MEKSYN. *Proc. Roy. Soc. A*, **207**, 370–80 (*July* 6, 1951).

The equation of the boundary layer

$$\frac{\partial^3 f}{\partial\sigma^3}+f\frac{\partial^2 f}{\partial\sigma^2}=2x\left(\frac{\partial f}{\partial\sigma}\frac{\partial^2 f}{\partial\sigma\partial x}-\frac{\partial^2 f}{\partial\sigma^2}\frac{\partial f}{\partial x}\right)$$

is integrated by successive approximations to find the self-consistent asymptotic solution for the motion downstream in the wake. A method is developed for integrating the linear equations which appear in connection with the motion in the wake close to the trailing edge of the plane. A.

533.6.011.5

6788. Application of homographic approximation to the study of supersonic flows. P. GERMAIN. *C.R. Acad. Sci., Paris*, **232**, 1811–13 (*May* 16, 1951) *In French.*

A number of investigators have pointed out that a fair approximation to the actual phenomena of supersonic flow is obtained if, in the rigorous equation of flow $K(\sigma)\psi_{\theta\theta}+\psi_{\sigma\sigma}=0$, a homographic function $\sigma/(\sigma+\alpha)$ in which α is a positive constant, and $\sigma+\alpha>0$, is introduced as an approximation for $K(\sigma)$ [See Abstr. 2442 (1951)]. Introduction of the variables $\theta'=\mu\theta$, and $\sigma'=\lambda\sigma$ results in the various equations obtained for different values of α to be reduced to one single equation, and if, furthermore, $\lambda^3=\mu^2$ and λ is increased indefinitely, the limiting equation is Tricomi's equation. Solutions obtained when $\alpha=1$ are discussed. The characteristics are cycloids, of which a parametric representation is obtained by taking $\sigma=-\sin^2\phi$. Solutions for the cases in which t is either real or complex are discussed briefly. The latter necessitates a preliminary discussion of the Riemannian surface of the function $\phi(t)$ defined by $(\sigma+1)\tan\phi-\phi-\theta+t=0$. The method of homographic approximation is applicable to the discussion of supersonic flows hitherto discussed by the use of Tricomi's equation, e.g. the supersonic flow past a profile in a channel having an undulated boundary wall. J. S. G. THOMAS

MOLECULAR THEORY OF GASES 533.7

533.7

6789. Intermolecular potentials. I. Carbon tetrafluoride and sulfur hexafloride. II. Carbon dioxide. K. E. MACCORMACK AND W. G. SCHNEIDER. *J. Chem. Phys.*, **19**, 849–55 (*July*, 1951).

Experimental second virial coefficient data for

CF_4, SF_6, and CO_2 have been used to investigate the intermolecular potentials of these molecules on the basis of a Lennard–Jones model. Force constants for the fluoride molecules can be fitted rather satisfactorily, but the constants so derived do not agree with those derived from other gaseous properties, e.g. the critical data. This result may be due to the assumption of central forces for the symmetrical fluoride molecules. For CO_2 it was found that the derived force constants varied with temperature, the high temperature data yielding lower values of the collision diameter r_0. The results can be interpreted on the basis of a partial association. A likely configuration for the resulting dimer is suggested. A.

533.7 : 536.23 : 537.565

6790. Convergence of the Chapman Enskog method for a completely ionized gas. R. LANDSHOFF. Letter in *Phys. Rev.*, **82**, 442 (*May* 1, 1951).

For H = O the calculations in Abstr. 794 (1950) are carried to a higher approximation. Some corrections are made to the equations. H. LONDON

533.7 : 536.71

6791. The third virial coefficients of polar gases. J. S. ROWLINSON. *J. Chem. Phys.*, **19**, 827–31 (*July*, 1951).

The third virial coefficient is calculated for a gas composed of spherical molecules whose intermolecular potential has a repulsive term proportional to r^{-12}, an attractive term proportional to r^{-6}, and which have point-dipoles at their centres. The calculated values are compared with the experimental results for steam and ammonia, using parameters previously calculated from the second virial coefficient. The agreement is good for ammonia but poor for steam. It is suggested that this is because of the neglect of the higher multipoles in the interaction potential. A.

533.75

6792. The critical constants of polar gases. J. S. ROWLINSON. *J. Chem. Phys.*, **19**, 831–3 (*July*, 1951).

The range of usefulness of the virial expansion is discussed. It is shown that this expansion closely resembles the Beattie–Bridgman equation if terms up to the third virial coefficient are included. This suggests that the ranges of validity of the two equations may be similar—namely, almost up to the critical density. The virial expansion is therefore used to calculate the critical constants of both nonpolar and polar gases. These constants are much less sensitive to the dipole-energy than are the virial coefficients. The agreement with experiment is satisfactory. A.

VIBRATIONS . ACOUSTICS 534

534.12

6793. Theory of air-coupled flexural waves. F. PRESS AND M. EWING. *J. Appl. Phys.*, **22**, 892–9 (*July*, 1951).

The theory of air-coupled flexural waves in a floating ice sheet is derived for the case of an impulsive point source situated either in the air or in the water. It is found that new branches are introduced to the dispersion curve of flexural waves as a result of coupling to compressional waves in the atmosphere. Experimental data are briefly reviewed.

534.1

6794. Waves in a flat speaking tube. B. I. ROSHDESTVENSKIĬ. *Dokl. Akad. Nauk, SSSR*, 7 (*No.* 2) 221–4 (1951) *In Russian.*

A conformal transformation changes the problem of excitation of a flat tube to a partial differential equation which can be solved in finite form. Two cases are discussed, a plane wave exciting the tube or a cylindrical one travelling from the broad to the narrow end. J. JACOBI

534.13 : 534.23

6795. The growth of subharmonic oscillations. W. J. CUNNINGHAM. *J. Acoust. Soc. Amer.*, **23**, 418–2 (*July*, 1951).

Subharmonic oscillations at one-half the frequency of excitation may appear in certain types of oscillating systems, among which is the direct-radiator loudspeaker. These oscillations occur at very nearly the resonant frequency of the system when the parameters of the system are made to vary at twice this frequency. The rate of growth of the subharmonic depends upon the amount of variation of the parameters relative to the dissipation in the system. If the dissipation is small, the rate of growth may be large. In the loudspeaker, conditions are such that the rate of growth is usually small for typical conditions of operation.

534.13 : 534.5

6796. The limitations of the principle of superposition. II. P. R. HEYL. *J. Wash. Acad. Sci.*, **4** 149–51 (*May*, 1951).

For Pt I see Abstr. 1765 (1951). Considers the kinetic energy, potential energy and acceleration of a body subjected to 2 simple harmonic motions of different frequencies; it is shown that addition of the amplitudes gives incorrect values for the energy, but that by multiplying the amplitudes by suitable factors results are obtained in accordance with the law of conservation of energy. A method is outlined for obtaining the factors in the general case of *n* different simple harmonic motions. N. CORCORAN

534.134 : 534.231

6797. On the possibility of purely mechanic transformers. Y. ROCARD. Note in *Rev. Sci., Paris* **88**, 236–8 (*Oct.–Dec.*, 1950) *In French.*

It is shown theoretically how these can be realized for longitudinal waves in a rod whose section varies exponentially along its length. Applications of the principle are outlined for matching the impedance of under-water acoustic microphones to that of the water and for amplifying piezo-electric vibrations. Mention is also made of possible applications with transverse and torsional vibrations. G. F. HODSMAN

534.213

6798. Erratum: Boundary layer attenuation higher order modes in rectangular and circular tube R. E. BEATTY, JR. Letter in *J. Acoust. Soc. Amer.* **23**, 481 (*July*, 1951). See Abstr. 1670 (1951).

534.22

6799. The propagation of sound in carbon dioxide near the critical point. N. S. Anderson and L. P. Delsasso. *J. Acoust. Soc. Amer.*, **23**, 423–8 (*July*, 1951).

The expression for the normal velocity of sound in a fluid becomes indeterminate at the critical point since the coefficient of elasticity tends to zero and the specific heat at constant pressure approaches infinity. An expression has been obtained for the isentropic slope which does not become indeterminate at the critical point. Observations were made with a Pierce type variable-path acoustic interferometer placed completely inside a pressure tank with provisions for external control. The isothermal variation of velocity and absorption was measured as a function of pressure at 572 kc/s in CO_2. Above the critical temperature it was found that, as the pressure increases, the velocity decreases steadily, goes through a sharp minimum, and rises abruptly. Below the critical temperature a discontinuity in velocity was observed between liquid and vapour. The velocity in the liquid at 29°c was 208 m/sec, and in the vapour 179 m/sec. The velocity variations away from the critical point agree with previously published results. The attenuation decreases steadily with increasing pressure and shows an abrupt rise as the critical point is reached, which would be expected from critical fluctuation scattering. Using isotherm data two values of the velocity at the critical point were calculated, 154 and 146 m/sec. The measured value was found to be 141·6 m/sec. A.

534.222

6800. An optical method for measuring the velocity of longitudinal and transverse ultrasonic waves in solids. A. Barone. *Ric. Sci.*, **21**, 513–15 (*April*, 1951) *In Italian.*

Employs the refraction of ultrasonic beams travelling from the solid specimen to a liquid whose acoustic parameters are known. The refraction angles are determined on a photographic record of the ultrasonic field obtained with the schlieren method. A.

534.222.2

6801. The solution of the Boltzmann equation for a shock wave. H. M. Mott-Smith. *Phys. Rev.*, **82**, 885–92 (*June* 15, 1951).

It is pointed out that the distribution of molecular velocities in a strong shock wave in a gas is bimodal. Assuming the distribution function to consist of a sum of two Maxwellian terms with temperatures and mean velocities corresponding to the subsonic and supersonic streams, it is found that the space distribution, as determined by the solution of a transport equation, is appropriate to describe a shock wave. Comparison of the solutions of two different transport equations shows that the assumed distribution changes relatively slowly with time and so is an approximate stationary solution of the Boltzmann equation for strong shocks. The shock thickness found is considerably greater than that given by previous theories. The nominal thermal conduction coefficient is negative in the after part of the shock. A.

534.222.2

6802. The production and stability of converging shock waves. R. W. Perry and A. Kantrowitz *J. Appl. Phys.*, **22**, 878–86 (*July*, 1951).

The experimental production of high temperatures and pressures by means of these converging shocks depends on their "stability" of form. A converging wave is said to be stable if it approaches perfect cylindrical or spherical shape, thus damping out random disturbances as it propagates. The experimental work of L. G. Smith on Mach reflection is applied to show that these converging waves are stable for the shock range ($M \leqslant 2{\cdot}4$) covered by his experiments. Smith's work and the theoretical work of Lighthill indicate that the stability decreases greatly at high Mach numbers. The simplest experimental method of achieving a cylindrical converging shock is by the use of a shock tube with a converging channel. This, however, results in the hottest region of the gas being in close thermal contact with the cold walls. An axially symmetric shock tube has been designed and constructed which produces a complete converging cylindrical shock rather than just a sector and in which the region of convergence is comparatively well isolated thermally from the walls. It has been found possible to converge a moderate strength shock wave ($M = 1{\cdot}7$) sufficiently to produce considerable luminosity at the centre of convergence. Schlieren photographs are presented showing various phases of the formation and stability of these converging waves. A.

534.23

6803. A method for determining the propagation constants of plastics at ultrasonic frequencies. H. J. McSkimin. *J. Acoust. Soc. Amer.*, **23**, 429–34 (*July*, 1951).

A pulse technique particularly suited to dissipative materials is described for measuring attenuation and phase shift constants of plastics, using either transverse or longitudinal waves in the frequency range of 5–50 Mc/s. A thin wafer of the material under test is placed between two identical fused silica buffers; and waves generated by quartz crystals at the ends of the assembly are transmitted simultaneously through the specimen in both directions. Comparison of transmitted and reflected components by means of a special balancing circuit provides information from which the complex propagation constant can be calculated, and hence dynamic rigidities and viscosities. Illustrative data for polyethylene and Nylon are given. A.

534.23 : 539.132

6804. Relaxation spectrum of glass. Y. L. Yousef and R. Kamel. Letter in *Nature, Lond.*, **167**, 945 (*June* 9, 1951).

Three absorption regions were observed at low audio frequencies. One is due to thermo-elastic relaxation and the other two to ionic migration.

R. O. DAVIES

534.23

6805. Dispersion of velocity and anomalous absorption of ultrasonics in nitrogen. A. J. Zmuda. *J. Acoust. Soc. Amer.*, **23**, 472–7 (*July*, 1951).

By means of the interferometer, the velocity and absorption of ultrasonic waves in N were measured at the frequency of 2·992 Mc/s, in the pressure range of 2·09 to 76 cm of Hg at a temperature of 29°c. A dispersion of velocity was found ranging from 354·3 m/sec to 364·4 m/sec. The ratio $\alpha_{exp}/\alpha_{class}$ dropped from 1·40 to 1·32, and the corresponding

value of C_v/R dropped from 2·50 to 2·08. Theoretical values for the change in velocity and in the absorption ratio, calculated by applying the equations for the exchange of energy between translational and vibrational degrees of freedom, show good agreement with the observed values. The increase in velocity and the decrease in $\alpha_{exp}/\alpha_{class}$ is interpreted as due to the slow exchange of energy between the translational and rotational degrees of freedom. The relaxation time for rotation was found to be $1{\cdot}2\times10^{-9}$ sec. A.

534.232

6806. On sound emission by means of a piston. D. N. CHETAEV. *Dokl. Akad. Nauk, SSSR*, **76** (*No.* 6) 813–16 (1951) *In Russian.*

The integral $\phi = \frac{v}{2\pi}\int_S\int\frac{e^{-ikr}}{r}dS$ arising as solution of $\Delta\phi + k^2\phi = 0$ is investigated subject to certain boundary conditions. An asymptotic solution for large k and a formula for a rectangular piston are deduced. J. JACOBS

534.232

6807. On the acoustical radiation of an emitter vibrating freely or in a wall of finite dimensions. J. PACHNER. Letter in *J. Acoust. Soc. Amer.*, **23**, 481 (*July*, 1951).

534.232 : 534.773.2 : 621.395.614

6808. Acoustic transducers for deaf-aids. W. GÜTTNER. *Fernmeldetech. Z.* [*FTZ*] **5**, 227–34 (*May* 1951) *In German.*

Deaf-aid microphones use Seignette salt (potassium-sodium tartrate) crystals or ammonium dihydrogen phosphate or a polarized ceramic, namely barium titanate. Types of oscillation, frequency and amplitude are discussed for crystals of various shape and mechanical structure. The ceramic crystal is non-hygroscopic. Saddle type crystals are used in both microphones and ear pieces for air as well as bone conduction. The frequency region covered extends from 300 to 4 000 c/s. Formulae and mechanical equivalents are given for certain electrical conditions. W. SUMMER

534.232 : 620.179.16 : 621.395.62

6809. The construction of efficient ultrasonic radiators. I. E. SKUDRZYK. *Elektrotech. u. Maschinenb.* [*EuM*] **68**, 173–8 (*April* 1, 1951) *In German.*

The piezoelectric effect is briefly described and minute details given for the chemical silvering of quartz surfaces. It is pointed out that such a method of applying voltage to a crystal is only satisfactory for low powers. Requirements of a high-power mount are considered, one-sided radiation and provision for uniform heating being stressed. Drawings are given of mounts developed both commercially and by the author for intensities up to 40 W/cm². Special attention is given to a totally-enclosed radiator for medical purposes in which the output is taken through a thin duralumin membrane. In this connection the problem of concentration of the radiation is studied. Preferred methods of irradiating fluids are described. A simple statement is made of the electromechanical theory of the transducer. S. C. DUNN (R)

534.2

6810. Sound scattering by solid cylinders and spheres. J. J. FARAN, JR. *J. Acoust. Soc. Amer.*, **23** 405–17 (*July*, 1951).

The theory of the scattering of plane waves o sound by isotropic circular cylinders and spheres i extended to take into account the shear waves whic can exist (in addition to compressional waves) i scatterers of solid material. The results can b expressed in terms of scattering functions alread tabulated. Scattering patterns computed on the basi of the theory are shown to be in good agreement wit experimental measurements of the distribution-in angle of sound scattered in water by metal cylinders Rapid changes with frequency in the distribution in-angle of the scattered sound and in the tota scattered energy are found to occur near frequencies o normal modes of free vibration of the scattering body. A.

534.321.7

6811. Standard musical pitch. F. W. ALEXANDER. *B.B.C. Quart.*, **6** (*No.* 1) 21–3 (1951).

Surveys briefly the values adopted during the las three centuries and the attempts made to establish a permanent standard, culminating in the 1939 con ference at Broadcasting House, London. A sche matic diagram is given of the crystal-controlle oscillator used for broadcasting the standard.

534.3

6812. Damping in acoustic resonators. K. VOELZ *Z. angew. Phys.*, **2** (*No.* 2) 67–72 (1951) *In German.*

Mathematical discussion on damping in cylindrica and spherical resonators, involving investigation of the inner damping of the oscillating medium and the effect of wall friction; the last being treated from the boundary layer aspect. The influence of heat conductivity on the oscillating medium is also considered W. W. GEHR

534.372

6813. On the damping of oscillating cylindrical rods by the surrounding medium. H. O. KNESER. *Z. angew. Phys.*, **3**, 113–17 (*March–April*, 1951) *In German.*

The influence of the surrounding air on the damping of torsional, flexural and stretching vibrations is deduced from observations on oscillating cylindrical rods over a wide frequency range. The effect of the air can be analysed into two parts: a frictional part, increasing as the square root of the pressure, which is alone detectable in torsional vibrations, and an effect increasing approximately as the pressure, associated with radiated sound waves, which predominates in the cases of bending and stretching vibrations. J. G. OLDROYD

534.61

6814. Ultrasonic intensity measurement. A. BARONE AND M. NUOVO. *Ric. Sci.*, **21**, 516–18 (*April*, 1951) *In Italian.*

When an ultrasonic beam is low-frequency modulated, a common microphone can be employed for measuring their intensity through the changes of the alternating component of the radiation pressure. An ultrasonic intensity meter based upon this principle is described. A.

534.611.08 : 621.3.011

6815. The decibel: conception and dimensional analysis. R. A. J. Bosschart and H. Freudenthal. *Ingenieur*, **63**, A203–A208 (*April* 27, 1951) *In Dutch.*

The usual application of the word "decibel" is critically examined. It does not appear to be a unit belonging to one of the current physical systems, but rather to mark a mathematical operator. It is proposed that decibel be put in sentences and in formulae in the same place as (in analogous cases), the other functional notations (log, sin, coeff), in the sense that dB is another notation for the operator 10^{10} log. For the unit of measurement of I, the logical consequence will be to write dB I = 60 + dB W. Then the transformation of one unit to another (Watt → kW) will be an additive one: dB kW = dB 10^3 W = dB 10^3 + dB W = 30 + dB W; thus dB I = 60 + dB W = 30 + dB kW. These general reflections are the starting-point for a criticism of the fundamentals of dimensional analysis, as they are usually formulated in investigations about this subject. A.

534.781

6816. A phoneme detector. C. P. Smith. *J. Acoust. Soc. Amer.*, **23**, 446–51 (*July*, 1951).

A speech analyser is described which measures the degree of fit between the energy distribution of any speech signal and a set of "standard" energy distribution patterns stored in the machine. This technique is based on the assumption that a phoneme can be characterized, at least for a single speaker, by specifying the points of energy concentration in the frequency spectrum and by specifying the energy envelope, i.e. energy *v.* time characteristic, of selected portions of the spectrum. A set of contiguous band filters covering the frequency range 100–7 000 c/s are used in combination with rectifiers and integrators to produce polarized signals which are functions of the energy distribution of the speech input signal. Improved selectivity and discrimination against noise and noise-like signals are obtained by combining the outputs from adjacent filters to measure the difference between signal levels, and further combining signals to measure the second difference between signals in adjacent filter bands. "Optimum filters" for phonemes are constructed by adding output signals corresponding to frequencies of energy concentration and subtracting signals corresponding to energy minima; this summation generates a signal proportional to the degree of "fit" between the speech signal and the specified pattern. Separate summations of the low and high frequency filter outputs provide measures of intensity, voiced-unvoiced detection, and pitch extraction signals. Some results are presented. A.

534.784

6817. A study of the vowel formants of well-known male operatic singers. C. S. McGinnis, M. Elnick and M. Kraichman. *J. Acoust. Soc. Amer.*, **23**, 440–5 (*July*, 1951).

The formant regions of vowels sustained by well-known male operatic singers were compared with each other and with those of untrained voices. Since vowel samples from commercial phonograph records were too short for electrical harmonic analysis, these samples were re-recorded on circular grooves. Analysis consisted of measuring the energy content of the individual harmonic partial tones. The result of this method seemed to be more informative in many ways than those obtained by using the sound spectrograph which shows only the general formant regions. Three important formants were found in the male voice, although the third of these was more prominent in trained voices. A fourth of minor importance occurred in trained voices only. The frequency positions of the three important formants are found to be in close agreement for the various voices analysed. A.

534.831

6818. An acoustical comfort index for aircraft noise. S. Lippert and M. M. Miller. Letter in *J. Acoust. Soc. Amer.*, **23**, 478 (*July*, 1951).

534.835/.836

6819. Levels and spectra of traffic, industrial, and residential area noise. G. L. Bonvallet. *J. Acoust. Soc. Amer.*, **23**, 435–9 (*July*, 1951).

A survey of city noise in the Chicago area was initiated in 1947. This report describes traffic, industrial and residential area noise which was investigated as a part of the work. Levels of traffic noise were 35 to 45 db, 45 to 65 db and 65 to 75 db in the 400–800 c/s band for light, average and heavy traffic conditions, respectively. Industrial noise ranged from 50 to 60 db in the same band for 50% of the cases measured. 90% were below 65 db. A limiting spectrum for noise which is considered not objectionable is presented. Residential area noise ranged from 38 to 47 db in the mentioned band for 50% of the cases measured. At night and for winter conditions, traffic noise was 10 db lower in the mentioned band than in the daytime. At night, industrial area noise dropped to levels of existing traffic conditions, and in winter it was lower by about 5 db in octave bands mainly because factory windows were closed. At night, residential area noise was 5 to 10 db less in octave bands than during the day, and for winter conditions there was a drop of 6 to 8 db in octave bands due to the modified character of distant traffic. A.

534.845

6820. Particular acoustical behaviour of a porous material. A. Bressi and G. G. Sacerdote. *Alta Frequenza*, **20**, 28–33 (*Feb.*, 1951) *In Italian.*

Material consisting of 3·3 mm thick layers of asbestos and glass wool, built up to total thicknesses of 3–12 layers, was placed at distances of 0–60 mm from a reflecting surface in a standing-wave measuring tube, and the absorption coefficient determined over the frequency range 200–500 c/s. The results are shown graphically and discussed in comparison with those for another material and with a simple theory of the low-frequency resonance. F. F. Roberts

OPTICS . RADIATION . SPECTRA 535

535.1 : 530.12

6821. Phase and group velocity in relativistic optics. M. Galli. *Rev. Opt. (Théor. Instrum.)* **30**, 174–84 (*April*, 1951) *In French.*

It has been suggested by Ditchburn [Abstr. 1794

(1948)] that phase velocity u and group velocity v of e.m. waves *in vacuo* may not be equal, provided they satisfy the relation $uv = c^2$. It is proved here that this conclusion does not conflict with relativity only if one assumes that, as a function of frequency, u does not depend on the motion of the source relative to the observer. L. PINCHERLE

535.14 : 538.561

Considerations regarding the emission of photons from sources of radio waves. *See Abstr.* 7111

535.214.6

6822. On transverse photophoresis. F. EHRENHAFT AND E. REEGER. *C.R. Acad. Sci., Paris*, **232**, 1922–4 (*May* 21, 1951) *In French.*

Describes experiments carried out at Sonnblick Observatory, 3 100 m above sea level, on photophoresis of graphite particles suspended in air or A at 5 to 10 mm Hg pressure, using solar light. A large proportion of freely falling particles were either accelerated or slowed down on entering the beam of light. The direction of the force introduced by photophoresis was always vertical, and did not bear any relation to the direction of the light. N. CORCORAN

535.31

6823. Generalization of the reflection formulae to the case of reflection of a wave of arbitrary form on a surface of arbitrary form. V. A. FOK. *J. Exp. Theor. Phys., USSR*, **20**, 961–78 (*Nov.*, 1950) *In Russian.*

Fresnel's formulae and the laws of Hamilton's ray optics are used for the derivation of the electromagnetic field of an arbitrary wave (i.e. non-plane wave) reflected on a general surface. The correction for the dilatation of the pencil of rays is used. The derivation is based on the tensor form of the differential geometry of the reflecting surface (the fundamental formulae of which are briefly derived and collected in a convenient form in the second section of the paper). The Gaussian parameters of the surface in the point of reflection and the phase of the reflected wave are considered as curvilinear co-ordinates. For the special case of a spherical wave reflected on a sphere the formulae are compared with the diffraction formulae. B. F. KRAUS

535.31

6824. The past and future of resolving power. G. TORALDO DI FRANCIA. *Atti Fond. "Giorgio Ronchi,"* **6**, 73–9 (*April*, 1951) *In Italian.*

Evidence from other fields of research indicates that no theoretical limit exists for the resolving power of an optical instrument. The theoretical limit concerns the maximum number of "units of information" that the instrument can transmit at a time. Other limits can be derived when the means of distributing and disposing of the available information has been decided. R. W. FISH

535.317

6825. A nomogram for estimating the optimum aperture of optical systems. F. I. HAVLICEK. Letter in *J. Opt. Soc. Amer.*, **41**, 483–4 (*July*, 1951).

The nomogram gives the optimum relative aperture for a system with a known Seidel coefficient of spherical aberration and with a given focal length. R. W. FISH

535.317.

6826. Notes on the definition of anallactic points. H. SCHULZ. *Optik*, **8**, 162–4 (*April*, 1951) *In German*

Recent expressions for anallactic points [see Abstr. 248–9 (1951)] are shown to be equivalent to earlier results. A simple geometric construction for the anallactic point is given. R. W. FISH

535.317.

6827. An achromatic doublet of silicon and germanium. R. G. TREUTING. *J. Opt. Soc. Amer.*, **41**, 454–6 (*July*, 1951).

The semi-metals Ge and Si have high transparency and high refractive indices over a wide range of infra-red wavelengths and are stable to normal atmospheres. Their relative indices and dispersions make achromatic combinations possible; and designs are given for axially corrected doublets of relative apertures $f/1$ and $f/1$. The optical homogeneity of the materials is discussed: compositional variations are not considered an optical hazard, but there is evidence of structural imperfections in some specimens whose effect on optical properties remains to be evaluated. A

535.317.

6828. New graphical methods for the determination of aberrational caustics in optical image formation. H. GONNERMANN. *Optik*, **8** (*No.* 3) 110–24 (1951) *In German.*

Graphs are given which determine, from the trigonometrically computed spherical aberration of the lens, the aberrational caustic and the position of any axial ray at the image plane. The method is extended to the case of a tangential fan of rays forming an extra-axial image. Means of calculating the intensity distribution in the image plane from geometrical considerations are also given. R. W. FISH

535.317.

6829. Graphical ray-trace and surface generation methods for aspheric surfaces. R. E. LEWIS. *J. Opt. Soc. Amer.*, **41**, 456–9 (*July*, 1951).

By means of geometric constructions, a series of solutions has been developed to perform marginal and paraxial ray-tracing on the drafting board. The methods are applicable to plano, spherical and aspheric surfaces. Mechanical analogue constructions of the ray-trace solutions are capable of generating Schmidt, parabolic, and other aspheric optical surfaces. The methods are applicable to the study of known designs, as well as to the development of curves to fit established or desired ray-traces. A

535.324–15

6830. Anomalous dispersion of carbon disulphide on both sides of the fundamental infra-red frequency at 1 523 cm^{-1}. J. RAMADIER-DELBÈS. *C.R. Açad. Sci., Paris*, **232**, 1920–2 (*May* 21, 1951) *In French.*

Using an interference method the refractive index of liquid CS_2 from 4·0–6·3 and 6·8–13·0 μ is measured. D. H. WHIFFEN

535.326 : 535.417

6831. An interferometric method for recording the refractive index derivative in concentration gradients. H. SVENSSON. *Acta Chem. Scand.*, **3**, 1170–8 (1949).

When studying concentration gradients in boundary systems, a simultaneous record of the concentration and its derivative is required. The concentration is

readily found with an interferometer, while a modification, using two beams passing through the system at slightly different levels, enables the derivative to be found. A suitable twin diffusion cell for this purpose is described in detail. R. W. FISH

535.326 : 535.417

6832. An optical arrangement for getting simultaneous records of the refractive index and its derivative for stratified solutions. H. SVENSSON. *Acta Chem. Scand.*, **4**, 399–403 (1950).

The inclined slit arrangement for the determination of the refractive index derivative can be transformed into a Rayleigh interferometer by changing the slits, and then records refractive index. A system having both slit systems side by side is used to record both functions simultaneously. The refractive index measurement is considered to be more accurate than the derivative measurement. R. W. FISH

535.326 : 535.417

6833. An interferometric method for recording the refractive index derivative in concentration gradients. II. Arrangement for and the theory of the purely optical differentiation of the refractive index function. H. SVENSSON. *Acta Chem. Scand.*, **4**, 1329–46 (1950).

This modification to the Rayleigh interferometer shifts the two interfering beams in the vertical direction by means of inclined glass plates. The theory indicates that the phase difference within the cell can be made proportional to the derivative at each point. The theoretical accuracy is $\pm 0{\cdot}2\%$ which compares favourably with other methods. Conditions for obtaining sharp fringes are discussed. R. W. FISH

535.326 : 535.417 : 541.124

6834. A refractometric method for following the non-stationary state of chemical reactions. N. GRASSIE AND H. W. MELVILLE. *Proc. Roy. Soc. A*, **207**, 285–301 (*July* 6, 1951).

Describes the construction of a cinematographic recording interferometer based on the Jamin type. By using the interferometer tubes as reaction cells the instrument has been used for following the photopolymerization of styrene, methyl methacrylate, methyl acrylate and vinyl acetate. The sensitivity of the apparatus permits the non-stationary phase of the reaction to be followed. In this way the velocity coefficients for the elementary steps of these reactions have been measured and compared with the values obtained by other non-stationary state methods and by the rotating sector technique. A.

535.33

6835. A geometrical representation of spectrum line series. F. FRAUNBERGER. *Optik*, **8** (*No.* 1–2) 31–7 (1951) *In German.*

535.33.03

6836. Excitation temperature in time-resolved spectra of single condensed spark discharges. L. BLITZER AND W. M. CADY. *J. Opt. Soc. Amer.*, **41**, 440–5 (*July*, 1951).

From relative intensities of Fe I lines, a study has been made of the excitation temperatures in short-time high-current condensed spark discharges, both in the integrated light from single sparks and from time-resolved spectrograms. In all cases a Boltzmann distribution of the atoms among the various excited energy-states has been found to exist, with the temperature as the distribution parameter. A statistical equilibrium between the electron gas and the excited atoms is presumed to exist, in which case the excitation temperature is the temperature of the electron gas. The spectrum of the initial phase of the spark is characterized by short-lived broadened lines of N II and O II. During the latter phase of the discharge (4–14 microseconds), in spite of extreme variations in current and radiation intensity from the source, the temperature was found to be approximately constant (6 000–7 000°K) both for damped and oscillatory discharges. A.

535.33.07

6837. The influence of the slit width of the spectrograph on the distribution of energy in the continuous spectrum. B. RIGHINI CRINO. *Ann. Astrophys.*, **14** (*No.* 1) 105–14 (1951) *In French.*

535.33.07 : 535.375.5 : 621.317.794

6838. Radiation measuring instruments for the infra-red to ultra-violet waveband. A. C. MENZIES. *Instn Elect. Engrs Paper* 1145, 11 *pp.* [*Early Proof Issue*].

A review of the techniques used in spectroscopy and related subjects in these regions, with special reference to direct detection and recording of spectra by electrical means. The change from photographic to electrical detection involves changes in spectrograph design, since for the former energy density, and for the latter total flux, is the quantity measured. Techniques for the individual regions are considered in detail. Very recent matters touched upon include a new highly-sensitive photoconductive cell for the visible and ultra-violet regions, and a new scanning equipment for Raman spectra. A. C. MENZIES

535.33.07–15

6839. Static multislit spectrometry and its application to the panoramic display of infrared spectra. M. J. E. GOLAY. *J. Opt. Soc. Amer.*, **41**, 468–72 (*July*, 1951).

The static multislit principle is examined, and some ancillary number theoretical concepts are discussed briefly. A discussion is also presented of the aberrations which limit the available field area in various spectroscopic systems. A description is given of an apparatus embodying the static multislit principle and designed to give a cathode-ray panoramic display of short segments of the i.r. spectrum in the NaCl and KBr prism range. The rate at which information about i.r. spectra can be obtained in this manner is illustrated by a photograph of the CO_2 spectrum which includes both the 14 μ and 15 μ absorption bands, and which was obtained in 100 msec. A.

535.33.072

6840. A medium resolution replica grating spectrophotometer. P. KRUMHOLZ. *Rev. Sci. Instrum.*, **22**, 362–4 (*June*, 1951).

Using the simplest optical parts a monochromator with a nominal bandwidth of about 15 Å was constructed, covering the range of 3 600 to 9 000 Å. This monochromator, in combination with suitable photocells and a direct-reading, linear, negative-feedback

amplifier, permits the determination of extinctions with an error of about 1·5%. The performance of the instrument was checked by measuring the absorption spectra of rare earth ions. A.

535.331

6841. On the doublet splitting of alkali terms. B. KOCKEL AND H. WAGENBRETH. *Ann. Phys., Lpz.*, **9** (*No.* 1) 1–5 (1951) *In German.*

Calculations of E. David [*Z. Phys.*, **91**, 289 (1934)] on Li are generalized to include the contribution to the splitting from exchange interactions of an outer *p*-electron with an inner *p*-shell. Numerical results for Li, Na, K (using Hartree or Hartree–Fock wave functions) differ from experimental values by 10–40%. W. J. SWIATECKI

535.338.331

6842. The third spectrum of copper (Cu III). A. G. SHENSTONE AND L. WILETS. *Phys. Rev.*, **83**, 104–8 (*July* 1, 1951).

An analysis of the second spark spectrum of Cu is given. The identified levels include all those due to $3d^9$, $3d^8 4s$, $3d^8 4p$ except the ^2S and ^2P based on $3d^8\ ^1S$. The six levels $3d^8(^3F)5s\ ^4F$, ^2F have been found and allow the calculation of an ionization potential of 37·08 V. A number of levels of $3d^8 4d$ are present also, but $3d^7 4s^2$, which should be lower, has not been found. A.

535.338.4

6843. On a band system ascribed to the CH molecule. M. W. FEAST. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 592–3 (*June*, 1951).

The bands ascribed to CH^+ by Gerö and Schmid [*Phys. Rev.*, **60**, 363 (1941)] are shown to have been due to Hg impurity.

535.338.4

6844. The $3p^3\Sigma \rightarrow 2s^3\Sigma$-bands of TH and T_2. G. H. DIEKE AND F. S. TOMKINS. *Phys. Rev.*, **82**, 796–807 (*June* 15, 1951).

The molecular spectra of TH and T_2 were photographed under high dispersion. The classification of the $3p^3\Sigma \rightarrow 2s^3\Sigma$-system is given for these two molecules as well as the molecular constants for the $3p^3\Sigma$-state. Irregularities in the structure including typical perturbations are accounted for by interaction with the $3p^3\Pi$-state. This system, with 58 known bands and more than 1 150 classified lines, is now known considerably better for T_2 than for any other species of H molecule, including H_2. A.

535.338.4

6845. The visible emission spectra of iodine and bromine monofluorides and their dissociation energies. R. A. DURIE. *Proc. Roy. Soc. A*, **207**, 388–95 (*July* 6, 1951).

A new emission band spectrum has been observed in the iodine-fluorine flame of reaction and has been assigned to the IF molecule. A similar type of spectrum is emitted by the bromine-fluorine flame and is shown to be an extension of the BrF system already known in absorption. Both these systems probably arise from a $^3\Pi_{0+} \rightarrow {}^1\Sigma$ transition. A Birge–Sponer extrapolation for the upper state of IF gives $D_0''(\mathrm{IF}) = 1{\cdot}98$ or $2{\cdot}87 \pm 0{\cdot}04$ eV, depending on whether the upper state dissociates to excited I and normal F or vice versa. Available evidence favour the lower value for $D_0''(\mathrm{IF})$ $(= 1{\cdot}98 \pm 0{\cdot}04$ eV i.e. upper state dissociates to excited I and normal F By analogy, if we assume the upper state of BrF dissociates to excited Br and normal F, a Birge Sponer extrapolation gives $D_0''(\mathrm{BrF}) = 2{\cdot}16 \pm 0{\cdot}02$ eV. A

535.338.4 : 539.13

6846. Contribution to the study of the free radical NH; experimental value for its energy of dissociation. G. PANNETIER AND A. G. GAYDON. *J. Chim. Phys.*, **48**, 221–4 (1951) *In French.*

The decomposition flame of N_3H and the flame of NH_3 burning in fluorine give NH-bands unmasked by those of N_2 or OH. Bands of the (1, 0) and (0, 1) sequences of the $^3\Pi \rightarrow {}^3\Sigma$-system have been observed for the first time. A vibrational analysis is given and a linear Birge–Sponer extrapolation gives $D_0 = 4{\cdot}0$ eV; a more likely value is 3·8 eV. A. G. GAYDON

535.339.

6847. Design of multiple-monochromators. A. WALSH. Letter in *Nature, Lond.*, **167**, 810–11 (*May* 19 1951).

An auxiliary double-mirror system converts a single into a double-monochromator giving increased resolution and a reduction in scattered radiation The method has been applied to an i.r. spectrometer R. W. FISH

535.34

6848. Influence of the width of the slit on the spectrometric determination of absorption bands. G. AMAT *C.R. Acad. Sci., Paris*, **232**, 1752–4 (*May* 7, 1951) *In French.*

Direct determination of the total absorption using a relatively wide slit is sometimes preferable to calculation of the coefficient of absorption using a narrow slit and extrapolation to zero slit width, followed by integrating with relation to frequency. W. R. ANGUS

535.343–14

6849. Further evidence for a two quantum transition in molecular spectroscopy. L. GRABNER AND V. HUGHES. Letter in *Phys. Rev.*, **82**, 561 (*May* 15, 1951).

The extra line group observed at 3·160 Mc/s arises as a two-quantum transition from a second-order time-dependent perturbation. J. JACOBS

535.343–14 : 535.338.334

6850. The theory of pressure broadening and its application to microwave spectra. M. MIZUSHIMA *Phys. Rev.*, **83**, 94–103 (*July* 1, 1951).

The calculation of the widths of several absorption lines in the microwave region is attempted. First, the Fourier integral formula for transition probability is deduced with the adiabatic assumption. Then the width and the shift of the absorption line are calculated, assuming the well type and the inverse power intermolecular potential. Applying the latter model, the width is calculated for several kinds of self-broadened microwave absorption line. A theoretical formula which gives the width of the NH_3 inversion line is obtained as a function of $K/[J(J+1)]^{\frac{1}{2}}$, where K and J are the rotational quantum number. It

agrees with experiment for large $K/[J(J+1)]^{\frac{1}{2}}$, and its temperature dependence is also good. In the microwave absorption of O, the quadrupole interaction is shown to be responsible for the width, and the theoretical result agrees with experiment if the quadrupole moment of this molecule is 2·5 to $2{\cdot}0\times10^{-26}$. It is also shown that the widths of the rotational lines of linear and symmetric top molecules can be explained by the dipole interaction. A.

535.343–14 : 538.22 : 539.152.2

6851. Spectroscopy at radio frequencies. C. J. GORTER. *Physica*, **17**, 169–74 (*March–April*, 1951).

Opening address of the international conference on spectroscopy at radio frequencies (Amsterdam, September 1950). A historical survey is given of the different branches of research, namely molecular radio frequency spectra, paramagnetic resonance, ferromagnetic resonance and nuclear resonance combined with atomic radio frequency spectra. A.

535.343 : 541.62

Substituted stilbenes. Absorption spectra. *See Abstr.* 7361

535.343–14 : 621.316.726.029.6

6852. Frequency stabilization by microwave absorption. H. R. L. LAMONT. *Physica*, **17**, 446–52 (*March–April*, 1951).

Describes a method of stabilizing the frequency of an oscillator by means of microwave absorption lines. Stabilization has been obtained for a number of ammonia lines near 1·25 cm wavelength, and a stability of ±6 parts in 10^7 measured. Possibilities for other wavelengths are considered. A.

535.343–15 : 539.13

6853. Perturbations in the region of infra-red absorption. P. BARCHEWITZ. *C.R. Acad. Sci., Paris*, **232**, 1750–2 (*May* 7, 1951) *In French.*

The influence of inter- and intra-molecular association on the infra-red spectrum of a molecule is discussed. W. R. ANGUS

535.343.2 : 535.372

6854. Absorption spectrum of thallium-activated potassium chloride phosphor at low temperatures. P. D. JOHNSON AND F. J. STUDER. Letter in *Phys. Rev.*, **82**, 976 (*June* 15, 1951).

A comparison of the experimental and calc. optical absorptions in the band near 5 eV due to Tl^+, at 4–298°K, of a crystal of KCl : 0·00021Tl grown from a furnace melt. The existence of zero-point energy of the calc. order of magnitude is indicated. J. GRANT

535.343.2 : 537.312.5

6855. The optical absorption and photoconductivity of rutile. D. C. CRONEMEYER AND M. A. GILLEO. Letter in *Phys. Rev.*, **82**, 975–6 (*June* 15, 1951).

TiO_2 has a characteristic absorption at 4 000 Å which is the fundamental lattice absorption at 3·06 eV. The calculated values of the optical absorption are supported by experimental values derived from the maxima of photoconductivity. W. SUMMER

535.343.2 : 548.7

6856. Note on the absorption spectra of pure and colored alkali halide crystals. D. L. DEXTER. *Phys. Rev.*, **83**, 435–8 (*July* 15, 1951).

The absorption cross-section per electron is calculated for ultraviolet radiation in NaCl at the first exciton band, at the exciton series limit, at the *F*-band and at its series limit. The assumed models lead to qualitative agreement with experimental results. The conclusions are briefly extended to other crystals. A.

535.343.2–15 : 535.375.54

6857. Interpretation of the infrared and Raman spectra of mixed crystals. H. J. HROSTOWSKI AND G. C. PIMENTEL. Letter in *J. Chem. Phys.*, **19**, 661–2 (*May*, 1951).

With molecule A in a dilute solid solution with molecule B there is no possibility of perturbations of the molecular vibrations of A due to coupling with identical molecular systems and this enables the influence of site symmetry alone on the spectrum of A to be studied. Similarly, in a dilute solid solution of a deuterated compound in the corresponding undeuterated compound, or vice versa, all spectral changes are due to coupling disturbances.

W. R. ANGUS

535.343.2–15 : 537.311.33 : 548.0

6858. Infra-red transmission of galena. W. PAUL, D. A. JONES AND R. V. JONES. Letter in *Proc. Phys. Soc., Lond. B*, **64**, 528–9 (*June*, 1951).

Some apparently pure single crystals of natural galena showed relatively high transmission to infra-red, commencing sharply at about 3 μ, with a peak at about 4·2 μ, and falling to 10% of peak at about 10 μ. The reasons for this unusual phenomenon are discussed.

535.343.3/.4–15 : 535.375.5

6859. Infrared and Raman spectra of methylhydrazine and symmetrical dimethylhydrazine. D. W. E. AXFORD, G. J. JANZ AND K. E. RUSSELL. *J. Chem. Phys.*, **19**, 704–7 (*June*, 1951).

Raman spectra for liquid methylhydrazine and sym-dimethylhydrazine, and infrared spectra for both liquid and vapour methylhydrazine and sym-dimethylhydrazine in the region 1 600–650 cm^{-1} have been obtained. Frequency assignments are proposed for methylhydrazine and sym-dimethylhydrazine. The strong polarization of the Rayleigh scattering from these two compounds is explained on the basis of associated structures of approximately spherical symmetry. A.

535.343.3–15

6860. Measurement of the relative infra-red absorption of the fundamental and first harmonic bands of some C–H vibrations. G. AMAT. *C.R. Acad. Sci., Paris*, **232**, 1821–4 (*May* 16, 1951) *In French.*

The ratios of the intensity of the fundamental CH stretching frequency absorption to its first overtone for $CHCl_3$, C_2HCl_5 and heptine, are 10, 23 and 120 respectively. D. H. WHIFFEN

535.343.3–31

6861. Deviations from Beer's law in the ultraviolet absorption spectra of some organic compounds. H. E. UNGNADE, V. KERR AND E. YOUSE. *Science*, **113**, 601 (*May* 25, 1951).

Deviations for phenols and acetoamino compounds derived from diphenyl ether are recorded. The majority of these resulted from density values of below 1·5, which are considered to be due to fluorescence. They are largest for C_6H_5OH, and

can occur in 95% alcohol solutions at concns. of down to 10^{-5} moles/l. In view of the widespread occurrence of these deviations, the concns. used in light absorption measurements should always be reported with the results. J. GRANT

535.343.3–31

6862. Ultraviolet absorption spectrum of fluoranthene. W. F. MADDAMS AND R. SCHNURMANN. Letter in *J. Chem. Phys.*, **19**, 973–4 (*July*, 1951).

535.343.31–15

6863. Intensities of some characteristic infrared bands of ketones and esters. S. A. FRANCIS. *J. Chem. Phys.*, **19**, 942–8 (*July*, 1951).

Integrated intensities of the 2 900, 1 720, 1 460, 1 370 and 1 200 cm^{-1} bands are reported for 4 ketones and 5 esters, and grating spectra are shown for the 2 780–3 060 and 1 300–1 500 cm^{-1} spectral regions. CH_3 and CH_2 structural group integrated intensities are derived from the data which are adequate for predicting the integrated molecular intensities of the bands in the 2 900, 1 460 and 1 370 cm^{-1} spectral regions. The data show that the carbonyl and ester structural groups reduce the intensities of the stretching modes and increase the intensities of the deformation modes of adjacent CH_3 and CH_2 groups. A number of empirical correlations are pointed out between positions of absorption maxima in the 2 900, 1 460 and 1 370 cm^{-1} regions and the internal molecular environment of CH_3 and CH_2 groups. A.

535.343.32

6864. The effects of added chlorides on the absorption spectra of cobaltous chloride in water and in formamide. L. R. DAWSON AND J. H. CHAUDET. *J. Chem. Phys.*, **19**, 771–4 (*June*, 1951).

It has been shown that alkali and alkaline earth chlorides widen, intensify and shift the absorption bands in the spectrum of $CoCl_2$ in water and in formamide. These effects appear to be directly related to the solvating power of the added cation. An interpretation of the observed phenomena has been presented on the basis of desolvation of the Co ion followed by interaction with Cl ions within the solution. In addition, probable mechanisms for the formation of the chloride complex and the resultant changes in the colour characteristics of the solution have been suggested. Reversals of the expected order of the effects of Na and K salts in water and of Ca and Sr salts in formamide have been shown. A.

535.343.32–31

6865. Near ultraviolet solution spectra of the diazines. F. HALVERSON AND R. C. HIRT. *J. Chem. Phys.*, **19**, 711–18 (*June*, 1951).

The near ultraviolet spectra of the diazines and various derivatives have been obtained in several solvents. Intensities, contours and positions of the observed bands are combined with a valence-bond treatment of the diazine π-electrons to assign the transitions and to evaluate the C–C and C–N exchange integrals. The diazine band near 30 000 cm^{-1} (3 333 Å) is assigned to a non-bonding nitrogen electron transition, and the band near 40 000 cm^{-1} (2 500 Å) to a π-electron transition. A.

535.343.4–1

6866. Microwave spectrum of NO_2. K. B. MCAFEE, JR. Letter in *Phys. Rev.*, **82**, 971 (*June* 15, 1951).

Six strong lines arranged as two triplets and their Zeeman splittings are given. D. H. WHIFFEN

535.343.4–1

6867. A high temperature, broad-band Stark cell for microwave spectroscopy. L. J. RUEGER, H. LYONS AND R. G. NUCKOLLS. Note in *Rev. Sci. Instrum.*, **22**, 428 (*June*, 1951).

535.343.4–14

6868. The microwave spectrum of sulfur dioxide. M. H. SIRVETZ. *J. Chem. Phys.*, **19**, 938–41 (*July*, 1951).

The *K*-band microwave spectrum of sulphur dioxide has been reinvestigated with results which are in agreement with the main points of the previously reported analysis by Dailey, Golden and Wilson. Some additional lines have been assigned, and new rotational constants have been derived which permit considerably closer agreement between observed and computed frequencies. From two of these the structural parameters $r(S–O) = 1{\cdot}432$ Å and $\angle(O–S–O) = 119{\cdot}53°$ can be obtained. The remaining discrepancy (of the order of 15 Mc/s for 10 lines involving J values up to $J = 35$) has been attributed to inaccuracies in the centrifugal distortion computation. A.

535.343.4–14 : 537.228.5

6869. The Stark effect of the ammonia inversion spectrum. D. K. COLES, W. E. GOOD, J. K. BRAGG AND A. H. SHARBAUGH. *Phys. Rev.*, **82**, 877–8 (*June* 15, 1951).

A detailed study of the Stark effect of certain transitions in the inversion spectrum of NH_3 has been made. The h.f.s. due to quadrupole and electric field effects is in agreement with theory. The value $1{\cdot}468 \pm 0{\cdot}009$ D has been obtained for the dipole moment. Consideration has been given to possible 2nd-order effects; their influence is shown to be negligible. A.

535.343.4–14 : 539 132

6870. The microwave absorption spectrum of nitrosyl chloride NOCl. J. D. ROGERS, W. J. PIETENPOL AND D. WILLIAMS. *Phys. Rev.*, **83**, 431–4 (*July* 15, 1951).

The spectrum has been studied between 21 000 and 23 000 Mc/s. Eight groups of closely spaced absorption lines have been observed; thirty-one individual lines have been resolved. The main features of the observed spectrum can be satisfactorily explained in terms of the rotational transition $J = 1 \rightarrow 2$ for molecules in the ground and lowest excited vibrational state; the observed hyperfine structure is satisfactorily explained in terms of nuclear quadrupole interactions involving the Cl nuclei. The rotational constants for molecules in the ground vibrational state are: for $NOCl^{35}$, $A = 2{\cdot}845$, $B = 0{\cdot}19141$ and $C = 0{\cdot}17934$ cm^{-1}; for $NOCl^{37}$, $A = 2{\cdot}854$, $B = 0{\cdot}18682$ and $C = 0{\cdot}17534$ cm^{-1}. Values for the quadrupole interaction terms are given. The ratio Q^{35}/Q^{37} was $1{\cdot}34 \pm 0{\cdot}08$. A.

535.343.4–14 : 539.133

Microwave spectra of trifluorosilane derivatives. *See Abstr.* 7175

535.343.4–15

6871. The hydrogen sulphide band at 1 183 cm^{-1}. R. H. Noble. Letter in *J. Chem. Phys.*, **19**, 799 (*June*, 1951).

535.343.4–15

6872. The carbon-hydrogen stretching modes of trioxane. J. C. Decius, W. C. Steele and R. G. Snyder. Letter in *J. Chem. Phys.*, **19**, 806 (*June*, 1951)

Infra-red spectrum 2 700–3 100 cm^{-1} and its partial interpretation. D. H. Whiffen

535.343.4–15

6873. Quantitative infrared intensity measurements. I. Carbon monoxide pressurized with infrared-inactive gases. S. S. Penner and D. Weber. *J. Chem. Phys.*, **19**, 807–16 (*July*, 1951).

Quantitative i.r. intensity measurements on CO pressurized with H^2, He, A, O_2 and N_2 for total pressures up to 700 lb/in² abs. have been carried out. The values of integrated absorption for the fundamental and first overtone of CO have been found to be 237 cm^{-2} $atmos^{-1}$ and 1·64 cm^{-2} $atmos^{-1}$, respectively. The numerical values of integrated absorption were obtained by using an indirect method for the interpretation of experimental data, similar to the extrapolation technique of Wilson and Wells. The experimental data obtained at very large values of the total pressure should yield correctly the numerical values of the spectral absorption coefficients. This statement is supported by the fact that the integral over the spectral absorption coefficients at a total pressure of 700 lb/in² abs. yields values for the integrated absorption of fundamental and first overtone of CO which are in excellent agreement with results obtained by indirect methods. A.

535.343.4–15

6874. Quantitative infrared intensity measurements. II. Studies on the first overtone of unpressurized CO. S. S. Penner and D. Weber. *J. Chem. Phys.*, **19**, 817–18 (*July*, 1951).

Quantitative absorption measurements have been carried out in cells of different lengths and at different pressures of gas. The experimental data lead to a value for the integrated absorption of the first overtone of CO of 1·69 cm^{-2} $atmos^{-1}$, which is in excellent agreement with results obtained previously from the study of mixtures of CO pressurized with infrared inert gases. A.

535.343.4–15 : 539.133

6875. Erratum: Rotation-vibration spectra of diatomic and simple polyatomic molecules with long absorbing paths. IV. The spectrum of methyl fluoroform (CH_3CF_3) from 19 μ to 0·7 μ. R. D. Cowan, G. Herzberg and S. P. Sinha. Letter in *J. Chem. Phys.*, **19**, 794–5 (*June*, 1951).

See Abstr. 2546 (1951).

535.343.4–32

6876. Ultra-violet absorption spectra of tin vapour in atmospheres of helium and hydrogen. W. R. S. Garton. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 591–2 (*June*, 1951).

535.343.4–32

6877. New absorption bands of the NO molecule in the extreme ultraviolet region. Y. Tanaka, M. Seya and K. Mori. Letter in *J. Chem. Phys.*, **19**, 979 (*July*, 1951).

Six bands of the $v' - 0$ progression of the system $E^2\Sigma - X^2\Pi$ have been observed. The heads of the 0,0 band are at 1 646·92, 1 646·30, 1 643·62 and 1 642·97 Å. [For state *E*, see Abstr. 946 (1951)]. R. F. Barrow

535.349

6878. Measurement of light absorption in microcrystalline powders. B. Mühlschlegel. *Ann. Phys., Lpz.*, **9** (*No.* 1) 29–39 (1951) *In German.*

By using a modified form of Gisolf's sphere, measurements of light absorption in powders can be given a quantitative interpretation. Calculations give a relatively simple relation between measured quantities and the diffuse absorption and transmission constants. Plausible results are obtained for CdS powders. G. F. J. Garlick

535.371

6879. Investigation of the mechanism of the luminescence of zinc phosphors when weakly excited. E. S. Krylova. *J. Exp. Theor. Phys., USSR*, **20**, 905–18 (*Oct.*, 1950) *In Russian.*

The phosphors investigated, viz. ZnS–Zn and ZnS–Cu, Co, exhibited the same mechanism of afterglow as the phosphor KCl–Tl, investigated earlier. In the absorption of the exciting light there is, in addition to the band of the fundamental absorption of the basic substance, electron emission from the centres of luminescence, the electrons being reabsorbed at comparatively short distances. The monomolecular character of the quenching for weak and short-lasting excitation proves that the electron after liberation from its localization level will as a rule recombine with the nearest ionized luminescence centre. This will, at a weak excitation, be that from which the electron was ejected. Thus, contrasting with the modern quantum-mechanical model of a phosphor, the thermal electron displaced in the crystal lattice no longer "belongs" to the whole crystal lattice, but only to a confined region of it, so that a distinction between an "own" and "foreign" electron, or "near" and "far" electron becomes useful. A monomolecular quenching process compatible with the recombination mechanism of the luminescence may be based on the experimental facts. Bloch–Wilson's semiconductor theory, on which the present phosphor models are based, does not admit of such a mechanism. Nor must the lattice of a ZnS phosphor be considered as rigid in relation to a thermal electron, as the latter in its displacements dislocates the nearest ions from their equilibrium positions; in other words, the thermal electron cannot be regarded as free in the lattice of the phosphor. The excited luminescence of these phosphors has a purely thermal character, which is proved by absence of fluorescence or similar short-lived processes at the time of the excitation. B. F. Kraus

535.371

6880. Fluorescence of 3,4-benzpyrene in frozen solutions. E. V. Shpolskiĭ and A. A. Ilina. *J. Exp. Theor. Phys., USSR*, **21**, 142–9 (*Feb.*, 1951) *In Russian.*

535.371

6881. Investigation of the photo-luminescence of the benzoylacetonates of europium and samarium. A. N. Sevchenko and A. K. Trofimov. *J. Exp. Theor. Phys., USSR*, **21**, 220–9 (*Feb.*, 1951) *In Russian.*

535.371

6882. Decay times of organic phosphors. W. Hanle, O. Kotschak and A. Scharmann. *Z. Naturforsch.*, **6a**, 202–6 (*April*, 1951) *In German.*

Using an ultrasonic cell fluorometer the decay times of organic phosphors are determined for u.v. and for electron excitation. The results are of special significance with respect to the use of these crystals for scintillation counters. G. F. J. GARLICK

535.371

6883. Phosphorescence of sodium chloride. M. Lautout. *C.R. Acad. Sci., Paris*, **232**, 2025–7 (*May* 28, 1951) *In French.*

The study on the decay of phosphorescence of NaCl, induced by irradiation with X-rays, has revealed the existence of 3 main processes the kinetics of which are different. It has been found that this phosphorescence can be reanimated by irradiating the crystal with waves of from 2 200 to 5 500 Å. The decay of the new phosphorescence is analogous to that of the initial phenomenon, but the duration of emission is *c.* 10 times shorter. Experiments with KCl have given identical results. F. LACHMAN

535.371

6884. Excitation of OH- and SH-band systems in fluorescence. P. J. Dyne and D. W. G. Style. Letter in *Nature, Lond.*, **167**, 899 (*June* 2, 1951).

Irradiation by a H discharge or by a Zn spark in N_2 produces excitation of the OH band at 3 064 Å in H_2O_2 at a low vapour pressure. The different band systems arising in H_2O and H_2O_2 are compared. Since the excitation requires a wavelength $< 1\,900$ Å, the experiments of Dawsey, Urey and Rice [*J. Amer. Chem. Soc.*, **51**, 1371 (1929)] are considered inaccurate. The SH band at 3 236 Å was similarly excited in H_2S. S. T. HENDERSON

535.371 : 537.311.33

Electron mobility and luminescence efficiency in cadmium sulfide. *See Abstr.* 6967

535.371 : 537.312.5

6885. Comparison of the relaxation of the photoconductivity with the relaxation of the phosphorescence. D. B. Gurevich, N. A. Tolstoĭ and P. P. Feofilov. *J. Exp. Theor. Phys., USSR*, **20**, 1039–46 (*Nov.*, 1950) *In Russian.*

Whereas the idea of comparing the phenomena of luminescence and photoconductivity goes back over 60 years (Elster and Geitel, 1891), not the same can be said where the kinetics of the two phenomena is concerned, although there were some investigations on the subject recently, using the taumeter method. The authors carry through a quite comprehensive comparison of all the empirical relations found for the initial stage (i.e. about 10^{-2} sec) of photoconductivity, both of the hyperbolical and exponential type of photoconductors, with those found for phosphorescence and fluorescence of ZnS phosphors, resulting in a far-reaching parallelism. As phosphorescence has a bimolecular recombinatio character, as distinct from the purely monomolecula or degenerated bimolecular character of fluorescence this corresponds to the hyperbolical photoresistances although there are cases, e.g. with few free electron and many holes, where a bimolecular process ma lead to an exponential law of quenching. Furthe points treated are the mechanism of spontaneou excitation and Becquerel's law. It is shown that th relaxation of the luminescence of CdS may be cal culated from the relaxation of its photoconductivity B. F. KRAU

535.371 : 537.312.

6886. A comparative study of photoconductivity an luminescence. R. H. Bube. *Phys. Rev.*, **83**, 393– (*July* 15, 1951).

Measurements of luminescence emission and photo conductivity as a function of (1) operating temperatur during excitation, (2) time during decay, and (3) tem perature during thermostimulation were made for a ZnS crystal. The results indicate that the processe of luminescence and photoconductivity are dissimilar Evidence is presented for the presence of surfac conductivity, especially important in measurement made with acicular crystals. A

535.37

6887. Influence of temperature and viscosity o absorption and emission of acridine derivatives. T. M Tarasova. *J. Exp. Theor. Phys., USSR*, **21**, 189– 203 (*Feb.*, 1951) *In Russian.*

535.37

6888. Influence of the water of crystallization on th fluorescence spectrum of uranyl nitrate. I. A. N Sevchenko, V. M. Vdovenko and T. V. Kovaleva *J. Exp. Theor. Phys., USSR*, **21**, 204–11 (*Feb.*, 1951 *In Russian.*

535.37

6889. Influence of the water of crystallization on th fluorescence spectrum of uranyl nitrate. II. A. N Sevchenko and B. I. Stepanov. *J. Exp. Theor. Phys. USSR*, **21**, 212–19 (*Feb.*, 1951) *In Russian.*

535.37

6890. Photoelectric measurement of fluorescence spectra of highly colored liquids. J. L. Lauer and E. J. Rosenbaum. *J. Opt. Soc. Amer.*, **41**, 450–3 (*July*, 1951).

An attachment to the Beckman quartz spectrophotometer modified with a multiplier photocell is described which, by utilizing surface illumination of the sample at close to grazing incidence, makes possible the measurement of fluorescence spectra of highly light-absorbing materials. Different monochromatic sources can be used for excitation. The apparatus is also suitable for light scattering measurements. A

535.375.5

6891. Raman spectra of several compounds containing phosphorus. T. J. Hanwick and P. O. Hoffmann. *J. Chem. Phys.*, **19**, 708–11 (*June*, 1951).

Raman spectra of water solutions of NaH_2PO_2, KH_2PO_2, HPO_3, $NaPO_3$, $K_4P_2O_7$, $K_2Na_2P_2O_7$, $K_2H_2P_2O_7$ and $Na_2H_2P_2O_7$ were photographed using a Hilger constant-deviation spectrograph, the 4 358 Å mercury line being used as the exciting radiation.

A system of liquid filters reduced the effect of the other mercury lines so that their presence was not objectionable. A Wollaston prism made possible the separation of the perpendicular and parallel components of the scattered radiation. Intensity and depolarization values were calculated from traces obtained by means of a Kipp and Zonen microphotometer. The Raman spectra of the NaH_2PO_2 and KH_2PO_2 solutions were identical, while those of the HPO_3 and $NaPO_3$ solutions differed markedly from each other. The spectra of the four pyrophosphate solutions were all similar in appearance, and their spectral lines showed similar relative intensities and depolarization values. Suggested models have been postulated. A.

535.376 : 537.542

6892. Phosphorescent effects with high energy radiation. M. Furst and H. Kallmann. Letter in *Phys. Rev.*, **82**, 964 (*June* 15, 1951).

An investigation is made of phosphorescence and optical stimulation of NaCl–Ag crystals after excitation by high energy particles and radiation. The performance of these crystals as scintillation and as storage detectors is discussed. G. F. J. GARLICK

535.376 : 537.542

6893. Response of some scintillation crystals to heavy particles. C. J. Taylor, M. E. Remley, W. K. Jentschke and P. G. Kruger. Letter in *Phys. Rev.*, **83**, 169 (*July* 1, 1951).

The response of anthracene, stilbene and NaI–Tl crystals to deuterons (1–5 MeV), H_2 ions (1–11 MeV) and α-particles (1–21 MeV) is studied. The organic crystals show a non-linear response over the energy ranges investigated, while NaI–Tl has linear response to protons and deuterons but a non-linear response to α-particles with energies < 6 MeV.

G. F. J. GARLICK

535.376 : 537.542

6894. The fluorescence efficiencies of some crystals for electrons and heavy particles. W. K. Jentschke, F. S. Eby, C. J. Taylor, M. E. Remley and P. G. Kruger. Letter in *Phys. Rev.*, **83**, 170 (*July* 1, 1951).

A comparison of fluorescence efficiencies of crystals for electrons of 500–5 000 eV and particles with the same specific energy loss (dE/dr) in the crystals is made. NaI–Tl shows a linear response to electrons of 1–624 keV, but anthracene only shows a linear response over a narrow energy range dependent on the type of incident particle. G. F. J. GARLICK

535.417

6895. Applications of multiple-beam interferometry. S. Tolansky. Letter in *Nature, Lond.*, **167**, 815–16 (*May* 19, 1951).

Two recent communications [Abstr. 4305, 6080 (1951)] on applications of multiple-beam interference methods to measurement of oscillations and of thin films, are criticized. The novelty of the methods proposed is discussed. S. TOLANSKY

535.417 : 531.715.1

6896. Two interferometric techniques. C. Volet and N. Cabrera. *Rev. Opt. (Théor. Instrum.)* **30**, 169–73 (*April*, 1951) *In French.*

A multiplication process ($\times 20$) is described whereby a 20 cm Fabry–Perot etalon is multiplied to measure a 4-metre distance between two mirrors. The radiation required is that of a single isotope like Hg^{198} to measure the etalon, and white light superposition fringes are used in the multiplication. The effect of the dispersion of the phase change on metallic reflection is investigated. This leads to fringe asymmetry. With the method a geodetic standard can be measured to some parts in ten million. The measurement of the metre in terms of light waves is discussed. S. TOLANSKY

535.417 : 531.717.1

6897. The measurement of thin film thickness by interferometry. S. Tolansky. Letter in *J. Opt. Soc. Amer.*, **41**, 425–6 (*June*, 1951).

A critical analysis of a method recently proposed by Schulz [Abstr. 5543 (1950)] for measuring thin film thickness by a Fabry–Perot interference method. A number of optical defects are pointed out. These apply mainly if the method is used in transmission with thin metal films. A number of the objections raised do not apply if measurements are made on dielectric films, or on metal films using reflection instead of transmission methods. S. TOLANSKY

535.417–15

6898. Wavelength calibration in the infrared by interference. C. V. Cooper and J. D. Stroupe. Letter in *J. Opt. Soc. Amer.*, **41**, 427 (*June*, 1951).

The familiar spectroscopic method of calibration with channelled white-light fringes is extended to the infrared, the interferometer consisting of parallel plates of NaCl. The range 0·5 to 15 μ is covered with 5 interference cells of plate separation 0·03 to 1·0 mm. Accuracy is better than $\pm 0{\cdot}01$ μ. Regions of atmospheric absorption are bridged by interpolation because of the known constant frequency separation of the fringes. S. TOLANSKY

535.42

6899. A method of determining common stray light for ruled gratings and other spectral apparatus. E. Ingelstam and E. Djurle. *Ark. Fys.*, **3**, *Paper* 6, 63–81 (1951).

Stray light is determined from the measured intensities at 5 825 Å with and without a didymium glass filter of known transmission, the spectral distribution being found by inserting additional colour filters. Corrections are made for the spectral curves of the illuminant and receiver. Practical details are given and the method is suggested as a routine test for gratings. 17 references. R. W. FISH

535.422

6900. Diffraction of homocentric rays. L. A. Pusset. *J. Exp. Theor. Phys., USSR*, **20**, 722–8 (*Aug.*, 1950) *In Russian.*

An exact solution near the focus with arbitrary wavelength is given. The field is completely determined by the known intensity and polarization of the illuminated part of a sphere of large radius surrounding the centre of the ray. J. JACOBS

535.43

6901. Some geometrical factors in light-scattering apparatus. J. J. Hermans and S. Levinson. *J. Opt. Soc. Amer.*, **41**, 460–5 (*July*, 1951).

The geometrical factors governing light-scattering

from rectangular and cylindrical cells are discussed. It is shown that the effect of refraction is to introduce a factor n^{-2} in the intensity measured in those cases where the receiver does not see past the edges of the primary beam. This is true irrespective of whether the cell is rectangular or cylindrical. If the receiver does see past the edges of the beam, the formulae for the amount of light received become more complicated. In connection with the expressions derived, the most preferable dimensions of the receiver slits are discussed. A.

535.434 : 541.64

6902. Expressions for turbidities. F. BUECHE, P. DEBYE AND W. M. CASHIN. Letter in *J. Chem. Phys.*, **19,** 803–4 (*June*, 1951).

For determining the size of polymer molecules of rod, sphere and coil shape, expressions for turbidity are given containing tabulated functions only. See also Abstr. 709 (1951). R. NEUMANN

535.52 : 548.0

Optical anisotropy of cubic crystals under quadrupole radiation. *See Abstr.* 7369

535.55

6903. Three-dimensional photoelasticity. R. C. O'ROURKE. *J. Appl. Phys.*, **22,** 872–8 (*July*, 1951).

The classical Sommerfeld–Runge method for deriving the laws of geometric optics in isotropic inhomogeneous media from Maxwell's equations is applied to problems in "weakly" anisotropic and inhomogeneous media. This leads to a generalized Hamilton–Jacobi partial differential equation for the phases of the two waves (eikonals) which can propagate with finite velocity in such a medium. By restriction to a limited class of stress distributions, a very powerful method of solving axially and spherically symmetric problems is derived which would be very difficult to treat by the direct solution of the classical equations of elasticity. The Maxwell–Neumann law is derived in variational form so that, in principle, in any given case the error involved in the conventional assumption that the paths are straight lines instead of the actual Fermat paths can be estimated. The last section treats the so-called general problem of photoelasticity in which the principal stress directions in the plane of the wave front rotate arbitrarily as the latter propagates through the medium. Again the Sommerfeld–Runge method gives a solution which claims that if the rate of rotation is small in a wavelength the contributions of the rotation to the integrated phase can be ignored. A.

535.568

6904. A wide-angle polariscope of great light-transmitting capacity with a doubling analyser. V. V. KAVRAĬSKIĬ. *J. Exp. Theor. Phys., USSR*, **20,** 619–23 (*July*, 1950) *In Russian.*

Reference is made to previous publications [*Journal of the Russian Physico-Chemical Society, Phys. Ser.*, **51,** 337–9 (1919); *Meteorological Journal* (*Russia*) **32,** 167–9 (1922) which, it is claimed, show that the priority in the invention of the instrument belongs not to Lyot (first reference in *C.R. Acad. Sci., Paris*, **177,** 1015 (1923)] but to the author. It is also claimed that the author used his instrument for the investigation on the polarization of the sky as early as 1919–20, i.e. 12 years before W. Voss's suggestion [*Die Himmelswelt*, **41,** 285–94 (1931)] Includes theoretical foundations and constructiona details of the instrument. F. LACHMAN

535.65 : 778.6 : 621.397.7

6905. Quality of colour reproduction. D. L. MACADAM. *Proc. Inst. Radio Engrs*, **39,** 468–8 (*May*, 1951).

Optimum reproduction needs to be identified. Since it depends upon the limitations of the repro duction process, as well as upon human vision and judgment, optimum reproduction will probably have to be determined for each process separately. The programme is to vary the production controls in systematic manners, measure the resulting colou reproduction in the best way known (e.g. the I.C.I method at the present time), submit the reproductions to visual judgment, and study the judgment data in comparison with the measurements in order to find significant correlations. The growing experience of such studies of colour photography is suggested as a guide. Preliminary estimates of optimum reproduction and of seriousness of deviations may be based tentatively on results of studies of noticeability of colour differences and on fragmentary results of studies of colour photography. These estimates can be improved as various parts of the programme are carried out. A.

535.8

6906. Efficient graticule illumination. C. VON HOFE. *Optik*, **8** (*No.* 3) 97–109 (1951) *In German.*

Optical systems are described for illuminating a graticule and projecting its image into a telescopic system with the greatest efficiency. The designs are such that the exit pupil of the telescope contains an image of the illuminating lamp, smaller in size than the pupil of the eye. Design equations of systems for use with astronomical and terrestrial telescopes, and with prismatic binoculars are derived from Gaussian optics. R. W. FISH

535.8

6907. An adjustable lens holder. E. J. TAPPERE. *J. Sci. Instrum.*, **28,** 209–10 (*July*, 1951).

The unit was devised to satisfy the need of mounting a wide range of objective lenses on a laboratory test bench, where it is undesirable to have separate cells produced for each new diameter and where the "vee" type of holder is considered unsuitable for the holding of high-quality cemented lenses. The design is simple in operation, gives light contact to the lens surfaces, accurate centring, full aperture, and holds the lens firmly without distorting it optically. It will accommodate lenses from $\frac{3}{4}$ in to 3 in dia. and from $\frac{3}{16}$ in to 1 in. in thickness. A.

535.8 : 612.72

6908. The geometrical and physiological magnification of optical instruments. N. GÜNTHER. *Optik*, **8** (*No.* 1–2) 38–45 (1951) *In German.*

The magnification of a magnifying glass, microscope or telescope is usually derived from geometric optics. The expressions obtained are shown to be special cases of the "physiological" magnification of an optical system and the eye. Experimental results

confirm the theory and demonstrate that the use of the "physiological" magnification overcomes certain inconsistencies of the geometrical method. R. W. FISH

535.8 : 621.385.833

6909. Microscopy by reconstructed wave fronts. II. D. GABOR. *Proc. Phys. Soc., Lond. B*, **64**, 449–69 (*June*, 1951).

Pt I, Abstr. 4712 (1949). The theory of diffraction microscopy is completed and extended in different directions. In this two-step method of image formation the object is reconstructed by optical means from a diffraction diagram, taken in coherent illumination with light or with electrons. The "projection method," originally described, and the "transmission method," recently proposed by Haine and Dyson, are two variants which can be treated by one theory. The process of image formation, the coherence requirements, and the conditions for a good reconstruction are discussed in detail. It is shown that the reconstructed image of extended objects suffers from some spurious detail, but this can be largely suppressed in the "dark-field" method of reconstruction, in which the illuminating wave is cut out after it has passed through the diffraction diagram. A.

535.81 : 537.312.5 : 621.383 : 666.1

6910. A method of sealing sapphire to glass and its application to infra-red photocells. R. P. CHASMAR, J. L. CRASTON, G. ISAACS AND A. S. YOUNG. *J. Sci. Instrum.*, **28**, 206–7 (*July*, 1951).

The requirements of window materials for recent forms of photo-conductive cells are discussed and various substances considered. Artificially grown sapphire is found to be a suitable material and one that is readily available. A method for sealing sapphire to glass is described. A.

535.81 : 666

6911. A method of sealing sapphire to glass. H. RAWSON. *J. Sci. Instrum.*, **28**, 208–9 (*July*, 1951).

A method is described for sealing sapphire windows to tubes of borosilicate glass using h.f. induction heating to make the seal. The results are described of sealing experiments carried out on certain sapphire-glass combinations with the aim of determining the best glasses to use in making the seals. A.

535.818.2 : 771.351

6912. The natural vignetting of photo-objectives. H. E. J. NEUGEBAUER. *Z. wiss. Photogr.*, **46** (*No.* 1–3) 11–15 (1951) *In German.*

The $\cos^4\theta'$ law of illumination in the image plane is derived and is shown to present difficulties in the case of telephoto or wide-angle lenses, or when field lenses are used near the image plane. Aberrations, particularly distortion of the entrance and exit pupils, are shown to influence the vignetting. R. W. FISH

535.818.2 : 771.351

6913. The natural vignetting of photo-objectives. H. E. J. NEUGEBAUER. *Z. wiss. Photogr.*, **46** (*No.* 1–3) 60–2 (1951) *In German.*

The necessary condition for a distortion-free image, and the existence of entrance and exit pupils independent of the field angles θ and θ', is shown to be that $\theta = \theta'$. The $\cos^4\theta'$ law of illumination is then identical with the $\cos\theta\cos^3\theta'$ law sometimes quoted. R. W. FISH

535.818.2 : 771.351

6914. The rôles of the cosine law and the exit pupil in the light distribution in the field of a photographic objective. E. WANDERSLEB. *Z. wiss. Photogr.*, **46** (*No.* 1–3) 16–60 (1951) *In German.*

The variation, with field angles θ and θ', of the illumination in the image plane is shown to be $\cos^4\theta$ and not $\cos^4\theta'$ or $\cos\theta\cos^3\theta'$ as sometimes given in the past. Distortion of the lens and vignetting by the lens mounts modify this law and methods of calculating these factors are given. The effective area of the entrance pupil controls the vignetting factor and it is demonstrated that, except when using a pre-lens diaphragm, distortion of the pupils modifies the $\cos^4\theta$ law. Results for typical lenses are quoted. 45 references. R. W. FISH

535.822 : 535.39

6915. The use of "coated" microscope optics. H. TRONNIER AND H. WAGENER. *Optik*, **8**, 165–72 (*April*, 1951) *In German.*

The theory of anti-reflection coatings is reviewed. Measurements of light transmission are reported for microscopes whose optics are coated. With the coated transmission taken as 100%, the transmission with the eyepiece uncoated is 85%, with the condenser uncoated 75%, with objective uncoated 70%, and with all three uncoated 45%. R. W. FISH

535.822.9 : 535.4

6916. The study of transparent objects with gradual phase variations by the method of phase contrast. H. ROYER. *Rev. Opt. (Théor. Instrum.)* **30**, 185–92 (*April*, 1951) *In French.*

Objects without discontinuities of phase often arise in practice, and the phase contrast image is derived theoretically for one case, a "thread" in a glass plate. Spurious fringes are shown to border the image of the "thread" unless the phase plate covers approximately $\frac{1}{50}$th of the central band of the diffraction pattern. Photographs illustrate the effect. R. W. FISH

535.89

6917. The use of "exploding wires" as a light source of very high intensity and short duration. W. M. CONN. *J. Opt. Soc. Amer.*, **41**, 445–9 (*July*, 1951).

The flash of light observed in discharging large condensers through a very thin wire has been used as a light source for obtaining photographs and for making visual studies of rapidly moving objects. Cu wire was found most suitable for photographic exposures. Wires made of Ag and Chromel gave good results in visual work. The energy emitted by an exploding Cu wire was determined by a photographic photometric reduction in 4 regions of the spectrum. The entire emission of a Cu wire of 2·5 cm length amounts to $(6\cdot5 \pm 0\cdot3)\times10^8$ watt/cm^2. Its emission in the visible region of the spectrum amounts to $9\cdot6\times10^8$ candle power/cm^2. The values show the great amount of energy available for this type of work and point to future use. An example is given of the application of exploding wires in an industrial technique, showing the formation of soap granules in the spray drying process. Arrangements for multiple flashes and means of exploding materials not available as thin wires are discussed. A.

HEAT 536

536.21

6918. Solution of certain unsteady heat flow problems by relaxation methods. A. GILMOUR. *Brit. J. Appl. Phys.*, **2**, 199–204 (*July*, 1951).

The use of relaxation methods to solve unsteady heat flow problems in which only one space dimension is involved is demonstrated by application to problems of heat transfer through the walls of highly insulated containers used for transporting frozen produce which requires low storage temperatures. In the problems considered various boundary conditions are encountered and these are readily dealt with by the relaxation technique. A.

536.212.2

6919. Heat conduction in simple metals. M. L. STORM. *J. Appl. Phys.*, **22**, 940–51 (*July*, 1951).

The partial differential equation of heat conduction is a non-linear equation when the temperature dependence of the thermal parameters (i.e. the thermal conductivity, K, and S, the product of the density and the specific heat at constant pressure) is taken into account. It is shown that a mathematical condition for the transformation to linear form of the one-dimensional, non-linear, partial differential equation of heat conduction is the constancy of

$$[1/(KS)^{\frac{1}{2}}](d/dT)\log(S/K)^{\frac{1}{2}}$$

This discovery is the motivation for an investigation of the relations between the thermal parameters of simple metals on the bases of the theory of solids and available experimental data. It is found that KS is essentially constant, its variation with temperature being much less than that of either K or S considered separately. It is also shown, as a result, that the condition for the above-mentioned transformation is valid for simple metals. Applications of the transformed equation to the solution of problems in heat conduction are considered. A.

536.212.2 : 536.48

6920. The thermal conductivity of some alloys at low temperatures. R. BERMAN. *Phil. Mag.*, **42**, 642–50 (*June*, 1951).

The thermal conductivities of German silver, stainless steel and constantan have been determined between 2 and 90°K and the electronic and lattice components of the conductivity have been calculated. The electronic conductivity is limited by scattering by "impurities." The lattice conductivity is limited by scattering of the lattice waves by electrons at the lower temperatures and by "impurities" at higher temperatures. A table is given showing the heat flow along specimens of each alloy resulting from temperature differences commonly met with in practice in low-temperature work. A.

536.41 : 536.63 : 536.71

6921. Study of the transition points of solid hexadecane and octadecane. R. BRESSON AND J. JAFFRAY. *C.R. Acad. Sci., Paris*, **232**, 1743–4 (*May* 7, 1951) *In French.*

Differential thermal analysis of hexadecane and octadecane has indicated specific heat anomalies at −22·5°C and −6·5°C respectively; these probably correspond to transformations of the second order. This is supported by the observed behaviour of th expansion coefficient which shows a maximum at th anomaly temperature in each case. F. E. HOAR

536.422.

6922. Vacuum evaporation of radioactive materials C. W. SHERWIN. *Rev. Sci. Instrum.*, **22**, 339–4 (*May*, 1951).

A method of separating P^{32}, Sr^{90} and Y^{90} by vacuu evaporation is described. The apparatus consist essentially of a movable W filament on which th radioactive material can be loaded and then evaporate by passage of increasing currents. Measurement o the filament's radioactivity gives the temperature evaporation characteristics of a given materia Impurities can only follow the pure radioactiv material if their temperature-evaporation curves ar similar. The evaporated material settles on a fixe "catcher" filament. 3 figures. G. WITTENBER

536.423.1

6923. The vapor pressure and critical constants o neopentane. J. A. BEATTIE, D. R. DOUSLIN AN S. W. LEVINE. *J. Chem. Phys.*, **19**, 948–9 (*July*, 1951)

The vapour pressure of neopentane has bee measured from 50° to the critical point. An equatio representing the observations is given. A study of th compressibility of neopentane in the critical regio gives for the critical temperature, pressure, volum and density the values: $t_c = 160{\cdot}60° \pm 0{\cdot}05$°C (Int.) $p_c = 31{\cdot}57 \pm 0{\cdot}03$ normal atmospheres, $V_c =$ 0·303 litre per mole (4·20 ml per g), $d_c = 3{\cdot}3$ mole/litre (0·238 g per ml). The uncertainty in th critical volume and density is 1%. A

536.423.4 : 533.

6924. Point of condensation and the volume de pendency of cluster integrals. S. KATSURA AN H. FUJITA. Letter in *J. Chem. Phys.*, **19**, 795 (*June* 1951).

536.424.1 : 541.183 : 548.

6925. Effect of the adsorption of gases on the poly morphic transformation $\alpha \rightleftharpoons \beta$ of quartz. P. STAHL *C.R. Acad. Sci., Paris*, **232**, 1669–70 (*April* 30, 1951 *In French.*

It has been shown that the temperature (570°C) o the allotropic transformation $\alpha \rightleftharpoons \beta$ of quartz varies in accordance with the nature of the gas presen (He, H, Ne, air A, CO_2 and H_2O have been used) This effect is connected with the adsorption of gases by the surface crystal lattice. F. LACHMAN

536.46

6926. Influence of flame front on the flow field. H. S. TSIEN. *J. Appl. Mech.*, **18**, 188–94 (*June*, 1951)

In the majority of cases the phenomenon is a very complicated one involving the heat transfer by conduction and radiation, the changes in concentration of the different components by diffusion and chemical reaction. Fortunately, as a result of the rapid rate of chemical reaction, the thickness of the flame front under ordinary conditions is generally very small, being less than 1 mm. Therefore, if one is interested in the influence of flame front on the flow field but not on the detailed structure of the flame, the flame can be assumed as infinitesimally thin, and only the final changes of the state of fluid due to combustion need be considered. A.

536.46 : 535.33

6927. The emission spectra of first-stage combustion in an engine. H. P. Broida, W. J. Levedahl and F. L. Howard. Letter in *J. Chem. Phys.*, **19**, 797 (*June*, 1951).

536.48

6928. Some properties of solutions of He^3 in He^4. I. Separation of the helium isotopes. B. N. Eselson and B. G. Lazarev. *J. Exp. Theor. Phys., USSR*, **20** 742–7 (*Aug.*, 1950) *In Russian.*

A method of separation has been developed in which the thermomechanical effect is used for removing He^4 and a rectification column for a second enrichment of the light isotope. A concentration of up to 1·5% of He^3 has been obtained. D. SHOENBERG

536.48

6929. Some properties of solutions of He^3 in He^4. II. Displacement of the λ-point and peculiarities of the transport effect. B. N. Eselson, B. G. Lazarev and I. M. Lifshits. *J. Exp. Theor. Phys., USSR*, **20**, 748–58 (*Aug.*, 1950) *In Russian.*

A lowering of 0·03°K has been found for the temperature of the λ-point of a 1·5% solution of He^3 in He^4. Peculiarities of the film flow of He II in a 1·5% and a 0·03% solution of He^3 have been investigated and explained. D. SHOENBERG

536.48

6930. Sub-critical flow in the helium II film. B. S. Chandrasekhar and K. Mendelssohn. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 512–13 (*May*, 1951).

Experiments on the flow of He II films under a thermal potential show that the flow rate is strictly proportional to the rate of heat input until a critical value is reached, above which the flow rate remains virtually unchanged. R. B. DINGLE

536.48

6931. Transport rates of the helium II film over various surfaces. J. G. Dash and H. A. Boorse. *Phys. Rev.*, **82**, 851–6 (*June* 15, 1951).

Liquid He II film transport over various surfaces has been studied by a new method in which a cylindrical capacitor using liquid He as the dielectric is employed as a depth gauge. Changes in liquid level resulting from film transport produce changes in capacitance which in turn cause frequency changes in a h.f. circuit. The details of this method are described. The film transport rates, measured to 1·25°K, were found to depend on the substrate; at 1·25°K, the highest rate observed was 51×10^{-5} cm³/cm sec for etched Cu and the lowest, $7 \cdot 5 \times 10^{-5}$ cm³/cm sec for glass. The rates were also measured over Fe in the magnetized and unmagnetized state and over a superconductor in the superconducting and in the normal state. No differences were noted. In the latter case the thermal conductivity of the container is abruptly changed and the absence of an effect supports the view that heat transfer plays no significant role in determining the transport rate. A.

536.48

6932. Periodic level controller for liquid nitrogen. B. Zweig. Note in *Rev. Sci. Instrum.*, **22**, 431 (*June*, 1951).

536.63

6933. A new method of measurement of the true specific heats of non-metallic materials. L. Weil. *C.R. Acad. Sci., Paris*, **232**, 1473–4 (*April* 16, 1951) *In French.*

An electrical method similar in principle to that for metals and suitable for ferrites. The specimens are in the form of disks with electroplated Pt layers on their faces, and rises in temp. of 2–4° in a few tenths of a second can be produced. The methods of measurement of temp. rise and of energy supplied are stated. The arrangement of two disks forming a cylinder is considered and figures given as to thermal leakage for various sizes of disks. [See also Abstr. 6182 (1951)]. S. WEINTROUB

536.654 : 539.132

6934. A new calculation of the latent heat of sublimation of carbon and the first C–H dissociation energy in methylene from electron impact data. F. H. Field. Letter in *J. Chem. Phys.*, **19**, 793 (*June*, 1951).

D(CH–H), or the energy required to remove H from CH_2, is either 84 or >89 kcal/mole, while the heat of atomization of CH_4, and the heat of sublimation of C are 357, and 135 kcal/mole, respectively. F. LACHMAN

THERMODYNAMICS 536.7/.8

536.7

6935. Thermodynamic properties of reactive gas mixtures. A. S. Campbell. *J. Franklin Inst.*, **251**, 437–52 (*April*, 1951).

By comparing the behaviour of a mixture of reactive gases in equilibrium but liable to disturbance with that of an identical mixture for which the condition of fixed composition has been stipulated, and by limiting the discussion to only one gaseous reaction being able to take place, it has been found that gas reactions may be divided into 3 groups, depending upon the algebraic sign of the product of the mole change and heat of reaction. The order of magnitude of the difference between the fixed-composition and chemical-equilibrium systems depends on the magnitudes of temperature, heat of reaction, heat capacities and a fourth quantity described as the mobility of the system. The precise manner in which the composition enters the problem is shown by the appearance of a composition function which is closely related to the mobility of the system. F. LACHMAN

536.7

6936. Availability and irreversibility in thermodynamics. J. H. Keenan. *Brit. J. Appl. Phys.*, **2**, 183–92 (*July*, 1951).

Connection is made between Gibbs' "available energy of the system and medium" and the criterion of stability. The available energy concept is developed for systems which communicate only with the uniform medium or atmosphere and for systems which communicate with an additional reservoir of specified temperature. The treatment is extended to problems of transient and steady flow. A measure of departure from the ideal, the irreversibility, is defined

and examined for its significance. Performance coefficients are devised for several classes of processes. Finally, the generality of the method is exhibited by analysis of a variety of thermodynamic phenomena. A.

536.7 : 518.5

6937. A simple analogue computer for thermodynamic calculations. H. R. DAVIDSON AND D. L. FULLER. *J. Phys. Coll. Chem.*, **55**, 200–3 (*Feb.*, 1951).

By means of a simple resistive network the equilibrium constant, K, for a chemical reaction $(= \exp [a/R(t + 273) + b/R]^{-1}$, where a, b are constants, t is temp. °C, and R the gas constant), is read directly from a voltmeter. A. J. KENNEDY

536.77

6938. Thermodynamic equilibrium. G. A. ELLIOTT. Letter in *Nature, Lond.*, **167**, 865–6 (*May* 26, 1951).

Extension of previous work [*Nature*, **165**, 934 (*June* 10, 1950) and Abstr. 1813 (1951)] in which is given a more detailed discussion of the general conditions of thermodynamic equilibrium when interchange of matter with the surroundings may occur.

F. E. HOARE

536.78 : 534.22

6939. Thermodynamics of the critical point. C. F. CURTISS, C. A. BOYD AND H. B. PALMER. Letter in *J. Chem. Phys.*, **19**, 801 (*June*, 1951).

Thermodynamic relations are derived connecting the velocity of sound, slope of vapour pressure curve and c_v at the critical point. It is also shown that the Joule–Thomson coefficient at the critical point is the reciprocal of the vapour pressure curve slope.

F. E. HOARE

ELECTRICITY 537

ELECTROSTATICS . DIELECTRICS 537.2

537.223 : 621.319.3 : 621.314.1

6940. Electrostatic direct-current transformer of 300 kilovolts. J. M. MALPICA. *Rev. Sci. Instrum.*, **22**, 364–9 (*June*, 1951).

An electrostatic transformer of direct current which permits the continuous transfer of electrical charges from a primary circuit to a secondary circuit by means of a rotating dielectric is described. The primary circuit consists of a pair of metallic brushes connected to a source of high voltage, the moving dielectric being placed between them. A similar pair of brushes, placed at a convenient distance away, constitutes the secondary terminals. The continuous transfer of charges permits the passage of a steady current from the secondary brushes. In the one-to-one ratio electrostatic transformer the secondary voltage is slightly less than the primary voltage due to losses, but since the primary circuit and secondary circuits are separated by insulating material, it is possible to place several disks on a shaft and to connect the primary brushes in parallel and the secondary brushes in series, obtaining in this way a step-up transformer. The elementary theory is developed and experimental results are shown. . A.

537.22

6941. Investigation of discharge curves of dielectri with several polarization mechanisms. N. S. Novo SILTSEV. *J. Exp. Theor. Phys., USSR*, **20**, 957– (*Oct.*, 1950) *In Russian.*

Where aperiodic processes occur, expansion i exponential functions is called for, e.g. for the tim relation of processes in dielectrics with appreciab relaxation times. The textbooks and literature i general do not cater for the requisite methods, excep for papers by Skanavi *et al.* [Abstr. 3145 (1950)] an by Tolstoi and Feofilov [Abstr. 4447 (1949)]. Th method consists in choosing the parameters of a equivalent circuit of capacitances and resistances i such a way that they yield a discharge curve simila to capacitors with the tested dielectric. If, on th other hand, the discharge curve is obtained b oscillograms, the parameters of the specimen may b calculated, but not selected. The paper supplement this method by extending it to several polarizatio mechanisms. The algebraic equations for determinin the coefficients of exponential expansions are easil written down and the number of terms required (thu the highest order of equation occurring in the system depends on the accuracy of the required solution.

B. F. KRAU

537.22

6942. Current theories of the ferro-electric stat H. LUMBROSO. *Rev. Sci., Paris*, **88**, 239–47 (*Oct.–Dec.*, 1950) *In French.* Review.

537.226.

6943. Investigation of dielectrics by means of c.r.o. N. S. NOVOSILTSEV. *J. Tech. Phys., USSR*, **21** 369–74 (*March*, 1951) *In Russian.*

A very simple oscillographic method and circu may be used for investigating the time-relation c dielectric processes. The circuit is described and th formulae given for "decoding" the traces on th screen (oscillogram would be a misnomer), for findin the capacitance and leakage losses of substances wit the same relaxation time. The character of th polarization processes, the presence of more than on polarization mechanism in a substance and the rat of action of these mechanisms may be diagnosed, an the order of magnitude of the dielectric losse estimated. Temperature and moisture influences o the dielectric processes investigated show up ver clearly. The method is explained with reference t investigations on ceramic dielectrics, Seignette salt an high-frequency polarization of annealed glass.

B. F. KRAU

537.226.

6944. Theory of polarization of dipolar liquids an gases in a constant electric field. II. Orientatio polarization of compressed dipolar gases and o solutions of dipolar substances in apolar solvents A. A. BORGARDT. *J. Exp. Theor. Phys.*, **21**, 436–4 (*March*, 1951) *In Russian.*

For Pt I see Abstr. 6193 (1951); see also Abstr 8725 (1950). The theory evolved in earlier papers fo dipolar liquids may be generalized to include dipola gases and solutions of dipolar substances in apola liquids. The limitations of the validity of the theor for solutions are determined by general consideration and also by special assumptions, such as that th

solvent must be apolar in the sense not only of the absence of a dipole, but also of quadrupole and higher moments (dioxane, CS_2); the solute must not form compounds in the solution. The comparison of the theory with experimental results is very satisfactory and permits of drawing a number of conclusions on character and degree of association of the solute by comparing the experimental relation, if any, $P_M(c)$, with the theoretical one. B. F. KRAUS

537.226.2

6945. Investigation of the polarization of barium titanate by the method of the transverse field. M. S. KOSMAN AND T. D. GOLDSHTEIN. *J. Exp. Theor. Phys.*, **21**, 528–31 (*April*, 1951) *In Russian.*

The effect of a transverse electric field on films of $BaTiO_3$ of high conductivity is not a direct alteration of the concentration of the current carriers, but of a secondary nature, viz. a mechanical deformation of the layer by the space charge set up in it. When it is assumed that the variation of the charge on the capacitor electrodes must always correspond to the variation of the charge in the dielectric, it may be concluded that the $BaTiO_3$ initially possesses a considerable internal conductivity and that its high effective dielectric constant is partly due to the latter. B. F. KRAUS

537.226.2

6946. Dielectric properties of HCl and DCl in solid state. M. COLIN AND S. E. PHILLIPS. *C.R. Acad. Sci., Paris*, **232**, 1924–7 (*May* 21, 1951) *In French.*

The dielectric constant (ε') and loss constant (ε'') of solid HCl and DCl were measured for frequencies varying between 80 c/s and 6 Mc/s. The results could be reproduced with an accuracy of *c.* 5%. HCl had a point of transformation at $100 \pm 0{\cdot}5°K$, DCl at $104{\cdot}7 \pm 0{\cdot}5°K$. At about 110°K and low frequencies, losses were observed that increased with temperature. It appears that the critical frequency lies considerably below 80 c/s. F. LACHMAN

537.226.2

6947. Ferroelectricity. B. T. MATTHIAS. *Science*, **113**, 591–6 (*May* 25, 1951).

Review of work since the phenomenon was discovered in Rochelle salt by Valasek (1920). Problems discussed include the occurrence of two Curie points for Rochelle salt, hysteresis effects for polarization against applied electric field, and the occurrence of a high value of piezoelectric constant along with the high dielectric constant. Busch and Scherrer (1935) discovered ferroelectric behaviour in KH_2PO_4 and KH_2AsO_4 with only one Curie point. $BaTiO_3$ was discovered to be an important ferroelectric in several countries at about the same time; single crystals were grown in Zürich in 1947. In 1949 the alkali niobates and tantalates as well as WO_3 were found to be ferroelectrics. Ubbelhode's theory of the free H-bond accounts for only one Curie point, although Mueller's theory bases the occurrence of two Curie points in Rochelle salt on mechanical interaction. Spontaneous polarization and other phenomena of these materials are described, and the influence of crystal structure on these properties is discussed. C. A. HOGARTH

537.226.2

6948. On the determination of complex dielectric constant of medium loss substances in the microwave region. K. V. K. PRASAD. Letter in *J. Chem. Phys.*, **19**, 797–8 (*June*, 1951).

Indicates very briefly a reflection method. D. H. WHIFFEN

537.226.2

6949. On the ferroelectric Curie point of tungsten oxide. S. SAWADA, R. ANDO AND S. NOMURA. Letter in *Phys. Rev.*, **82**, 952–3 (*June* 15, 1951).

Tungsten oxide has ferroelectric properties, and the Curie point is at about 710°C. E. RUSHTON

537.226.2 : 537.311 : 621.315.61

6950. The electrical constants of soil at ultra-high frequencies. P. N. SUNDARAM. *Indian J. Phys.*, **24**, 469–78 (*Nov.*, 1950).

A detailed study of the variation of the dielectric constant and conductivity of soil with frequency, sand content and moisture content has been made within the wavelengths between 4 and 7 m. A modified Lecher-wire system, completely immersed in the soil for the required length, was used for recording observations. A.

537.226.2 : 541.182

6951. Electrical parameters of disperse systems. E. M. FRADKINA. *J. Exp. Theor. Phys., USSR*, **20**, 1011–18 (*Nov.*, 1950) *In Russian.*

The electrical parameters of disperse systems are calculated for not too low concentrations of the disperse phase. The theory is based on an expression derived by Frenkel for the electric moment induced in a conducting spherical drop submerged in a dielectric under the influence of an external field. The influence of the diffuse ionic boundary layers is also considered. It is possible to determine then both the real and imaginary parts of the complex dielectric constant and its conductivity under the condition that the product of inverse radius of the ionic atmosphere and particle radius $\ll 1$. The discussion of the results shows that the real diel. const. then varies as the relative drop volume, concentration and square of drop radius, whereas the conductivity $\propto$ rel. drop vol., square of drop radius and squared field frequency. The analysis is then specialized for aqueous solutions of strong electrolytes, using the Debye–Falkenhagen theory. The conclusions arrived at and specifically applied to petroleum emulsions are that for these the diel. const. is independent of the concentration of the salts in water, of the degree of dispersity and of the frequency of the external field, and only depends on the volume concentration of the disperse phase (wetness of the system). The experimental test of the theory, i.e. the measurement of the diel. constant of actual petroleum solutions was carried out by Drude's second method on the wave $\lambda = 1{\cdot}66$ m. The experimental results confirmed the theoretical ones. B. F. KRAUS

537.226.2 : 621.3.015.5 : 621.3.017.143 : 621.315.612

6952. Dielectric losses and breakdown of ceramic materials. I. Electric conduction and breakdown of solid insulators, in particular glass. K. J. KELLER. *Voordr. K. Inst. Ing., No.* 29–31, 485–520 (*May*, 1951) *In Dutch.*

The results of fundamental research are reviewed. The experimental results fairly agree with the existence of a critical temperature (Fröhlich) below which the electric strength increases and above which the electric

strength decreases with temperature. Admixture of electron scattering centres shifts the critical temperature to lower values. From the point of view of breakdown the critical temperature of an insulator should be near the working temperature in practical applications.

II. Dielectric losses in ceramic materials. J. H. VAN SANTEN.

Dielectric losses may arise from various causes: d.c. conductivity (leak), relaxation processes and vibrations. For some simple theoretical models the dependence of dielectric losses on frequency and temperature is discussed. The losses of an ideal insulating single crystal are shown to be negligible. Losses arise, however, in the case of deviations from the ideal structure, i.e. as a result of physical and chemical impurities. In this connection the work of Breckenridge on alkali halides is discussed. It is suggested that the dielectric losses in ceramic materials are essentially of the same type as discussed for single crystals.

III. Dielectric losses in glass. J. M. STEVELS.

The loss angle of glasses is discussed as a function of the frequency f, the temperature T and the chemical composition, both from a theoretical and a practical point of view. A three-dimensional model, showing the relation between $\tan\delta$, f and T is described. The influence of the chemical composition on the power factor is discussed in detail. A.

537.226.2/.3 : 535.343.4–14

6953. Dielectric constant and loss factor of ethyl alcohol and water at $\lambda = 3{\cdot}24$ cm obtained by free wave method. M. YASUMI, H. OKABAYASHI, M. SHIRAI AND S. MIZUSHIMA. Letter in *J. Chem. Phys.*, **19,** 978–9 (*July*, 1951).

537.226.2/.3 : 621.317.374 : 621.335.3

6954. Automatic measurement computation and recording of dielectric constant and loss factor against temperature. E. B. BAKER. *Rev. Sci. Instrum.*, **22,** 376–83 (*June*, 1951).

An automatically computing and recording instrument for dielectric constant and dielectric loss as a function of temperature at any constant frequency from 50 to 600 000 c/s is described. Sample curves are shown. Known magnification and zero shift are incorporated to cover the ranges of values encountered in most plastic materials. Automatic correction for and measurement of thermal expansion is incorporated. A.

537.228.1

6955. Piezoelectric characteristics of Seignette salt in the direct piezoeffect. M. S. KOSMAN AND K. N. KARMEN. *J. Exp. Theor. Phys., USSR*, **21,** 524–7 (*April*, 1951) *In Russian.*

According to available data in the literature, the piezo-modulus of the direct effect is $10\times$ greater than that of the inverse effect. Authors prove that in reality they are identical. The erroneousness of some notions about the piezoelectric characteristics of Seignette salt is pointed out. Electric field and mechanical stress are absolutely equivalent for the Seignette salt and fully interchangeable. Polarization in the electric saturation field and under mechanical stress are equal, but the correct value can only be obtained from the complete P *v.* stress curve. The most probable value of P_0 is $(22 + 2)\times10^{-8}$ C/cm^2 the differential value of the piezo-modulus in th range of the maximum slope of the P-stress curv being about 240×10^{-5} CGSE/dyne. Variation of on transition from saturation under tensile stress t saturation under compression of crystal represent value $2P_0$. By the usual method of determination c P the correct value of P_0 may be found as the ½-sur of the saturation polarization in two positions of th crystal with an angular difference of 90°. Th differential piezo-modulus is determined in th original state of the crystal. The electrode form an moisture conditions are also important for correc determination of piezo-modulus. Temperature re lations are not considered. All the measurement were made at 14–18°C, where the piezo-modulus i practically independent of temperature, and polariza tion also. B. F. KRAU

537.228.

6956. Elastic and electromechanical coupling coef ficients of single-crystal barium titanate. W. L. BOND W. P. MASON AND H. J. MCSKIMIN. Letter in *Phy Rev.*, **82,** 442 (*May* 1, 1951).

Large multi-domain single crystals were polarize by a high electric field to orient the domains with thei ferroelectric axes predominantly in the direction c the thickness of the crystal plate. The ultrasonic puls technique was used and measurements were made c the velocity and amplitude of longitudinal and shea waves. Measurements were made of the resonan and anti-resonant frequencies of a series of orientation polarized along the thickness along the cubic axis Full details are given of the results. A. C. WHIFFI

ELECTRIC CONDUCTION . CURRENTS 537.

537.311.

6957. The behaviour of electrons in ionic crystals F. F. VOLKENSHTEĬN AND V. L. BONCH-BRUEVICH *J. Exp. Theor. Phys., USSR*, **20,** 624–35 (*July*, 195 *In Russian.*

The question of conduction is treated as a many electron problem and solved for the case of 2 electrons Apart from Bloch-type states others are admissibl corresponding to paired electrons. Such electro pairs result from inclusion of exchange interactions. J. JACOB

537.311.3

6958. New temperature relations for Seignette sal M. S. KOSMAN AND A. N. SOZINA. *J. Exp. Theo Phys., USSR*, **20,** 1116–22 (*Dec.*, 1950) *In Russian.*

The investigations were intended to clarify th nature and causes of the large discrepancies in measure ments of the resistivity of Seignette salt by differen authors. A novel measuring method was devised fo the purpose which permits of measuring very sma temperature differences. It was found that fo temperatures below the upper Curie point (24°c) th current through the salt decreases continuously i time, this decrease being observable for 24 hr an longer after the impression of a voltage on the crysta An increase of the field applied leads to a stee

increase of the current, after which a new fall follows. This process is most suitably described as a "formation" of the crystal, or emergence of a barrier layer. Since the quantity of electric charge required for stepping up the resistance of the crystal is commensurable with the charge accumulated in it, the second term seems more appropriate. The resistance of a crystal 0·08 cm thick with 300 V across it becomes 3 orders of magnitude higher than that found by Valasek [*Phys. Rev.*, **20**, 639 (1922)] for 15–35°c. Barrier layers formed at temps. below Curie point are more stable even at higher temps. where they cannot be obtained. Such barrier layers, when formed, increase the resistance in such a degree that conductivity losses of charge even under strong applied fields are only a few % per hr. The pyro-effect in Seignette salt can be interpreted as depolarization of residual charges set up by a field preliminarily applied. B. F. KRAUS

537.311.32

6959. The mobility of electrons in silver chloride. J. R. HAYNES AND W. SHOCKLEY. *Phys. Rev.*, **82**, 935–43 (*June* 15, 1951).

Techniques are described which utilize the "print out effect" to obtain both the direction and velocity of photoelectrons in AgCl crystals in an electric field. Hall mobility of the electrons is calculated from their change in direction produced by crossed electric and magnetic fields. Drift mobility of the electrons is obtained by measurement of their velocity in known electric fields. The value obtained for the Hall mobility ($R\sigma$) multiplied by $8/3\,\pi$ is 51 cm²/volt sec at 25°c. The values obtained for the drift mobility are shown to be a function of temperature. A value of 49·5 cm²/volt sec was obtained at 25°c, which is within experimental error of $(8/3\,\pi)R\sigma$, indicating that acoustical scattering is the principal mechanism and that temporary trapping is unimportant. A summary of the behaviour of conduction electrons in AgCl, calculated from the results of these experiments, is included. A.

537.311.33

6960. Theory of the contact of two semiconductors of the same type of conductivity. A. I. GUBANOV. *J. Tech. Phys., USSR*, **21**, 304–15 (*March*, 1951) *In Russian.*

Schottky and Spenke's theory of the contact between a metal and a semiconductor which considers the contact p.d.'s [*Wiss. Veröff. a.d. Siemenswerken*, **18**, 1 (1939)] may be transferred without difficulty to 2 semiconductors of the same type of conductivity, although the boundary conditions will have to be changed. The results are correspondingly different in important points, among which the fact stands out that a large p.d. will not always entail a particularly strong rectifying effect. On the other hand, the calculations furnish a check on the theory of the metal-semiconductor contact which now appears as the limiting case of the more general theory of the contact between semiconductors of the same conductivity type. In all cases the rectifying effect between 2 semiconductors of equal type is weaker than that between metal and semiconductor, and still less appreciable at large current densities where under certain conditions the direction of the rectification may even be inverted against that at low current densities. At a great difference in the values of the conductivities of the 2 semiconductors the formulae of the theory become identical with Schottky–Spenke's formulae for the metal-semiconductor contact, which proves the above statement about the limiting case of the theory. B. F. KRAUS

537.311.33

6961. The electrical conductivity of simple *p*-type semiconductors. A. LEMPICKI. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 589–90 (*June*, 1951).

Discusses the theory on the same basis as earlier treatments of *n*-type semiconductors [Abstr. 2455 (1950)].

537.311.33

6962. Temperature dependence of the energy gap in semiconductors. H. Y. FAN. *Phys. Rev.*, **82**, 900–5 (*June* 15, 1951).

The problem treated is the effect of lattice vibrations in producing a shift of the energy levels which results in a temperature dependent variation of the energy gap in semiconductors. Calculations for Si and Ge give results of the same order of magnitude as the observed temperature dependent shift of the absorption band edge. The effect of lattice vibrations on the energy gap has been treated previously on the basis of broadening rather than shifting of the energy levels. The effect was found to be negligible for non-polar crystals, whereas according to our treatment it should be much larger. For polar crystals our result turns out to be essentially the same as was given by the previous treatment. A.

537.311.33

6963. Some electrical properties of zinc oxide semiconductor. E. E. HAHN. *J. Appl. Phys.*, **22**, 855–63 (*July*, 1951).

Measurements of the dark electrical conductivity σ, and Hall coefficient were made on sintered spectroscopically pure ZnO powder samples over a temperature range from 100°K to 625°K and at room temperature on ZnO crystals containing Pb impurities, using both the usual d.c. potentiometer-probe method and an a.c. (4 000 c/s) set. In this reproducible range, $\ln\sigma$ is not linear with $1/T$ for the sintered samples but exhibits maxima occurring at higher T and σ values, the higher the sintering temperature; the electronic carrier concentration of the different samples, calculated from the Hall data, indicates thermal ionization of $1\cdot6\times10^{16}$ to $9\cdot0\times10^{17}$ donors/cm³ lying 0·017 to 0·045 eV below the conduction band, with increasing ionization energy and increasing donor concentration, in general, occurring for higher sintering temperatures. Conductivity measurements are also made on sintered samples from 300°K to 1 040°K using the a.c. (4 000 c/s) voltmeter-ammeter method; above about 650°K, $\ln\sigma$ *v.* $1/T$ is linear and in agreement with the results of previous workers with ionization energies varying from 1·4 to 2·4 eV. Back reflection X-ray patterns indicate an increase in the lattice spacing after sintering; the change can be correlated with the presence of interstitial Zn atoms. The forbidden gap is taken to be about 3 eV, corresponding to an ultraviolet absorption edge and luminescence peak at 3·2 eV; the yellowing of worked

or highly conducting or heated samples is attributed to a shift of this absorption edge into the visible. Room temperature impedance measurements show a frequency dependent reactance and resistance attributable to capacitive shunting of the high resistivity grain boundaries ($\nu \sim 10^7$ c/s). It is shown that the l.f. conductivity of the sintered samples is determined by the conductivity and relative thickness of the grain boundary material while the Hall coefficient depends mainly on the carrier concentration in the semiconducting grains; uncritical use of l.f. and d.c. results would thus lead to spuriously low values of the conductivity and mobility in relation to the true properties of the grains. A.

537.311.33

6964. On the dispersion of resistivity and dielectric constant of some semiconductors at audiofrequencies. C. G. KOOPS. *Phys. Rev.*, **83**, 121–4 (*July* 1, 1951).

Semiconducting $Ni_{0.4}Zn_{0.6}Fe_2O_4$, prepared in different ways, has been investigated. It appeared that the a.c. resistivity and the apparent dielectric constant of the material show a dispersion which can be explained satisfactorily with the help of a simple model of the solid: there should be well-conducting grains separated by layers of lower conductivity. Dispersion formulae are given. There is good agreement between experiment and theory. A.

537.311.33

6965. *p–n* junction transistors. W. SHOCKLEY, M. SPARKS AND G. K. TEAL. *Phys. Rev.*, **83**, 151–62 (*July* 1, 1951).

The effects of diffusion of electrons through a thin *p*-type layer of Ge have been studied in specimens consisting of two *n*-type regions with the *p*-type region interposed. It is found that potentials applied to one *n*-type region are transmitted by diffusing electrons through the *p*-type layer although the latter is grounded through an ohmic contact. When one of the *p–n* junctions is biased to saturation, power gain can be obtained through the device. Used as "*n–p–n* transistors" these units will operate on currents as low as 10 μA and voltages as low as 0·1 V, have power gains of 50 db and noise figures of about 10 db at 1 000 c/s. Their current-voltage characteristics are in good agreement with the diffusion theory. A.

537.311.33

6966. Electric forming in *n*-germanium transistors using phosphorus-alloy contacts. J. P. STELMAK. Letter in *Phys. Rev.*, **83**, 165 (*July* 1, 1951).

Pulsing tests made with phosphor-bronze emitter and collectors of copper containing small quantities of P show that power gain is markedly increased for P contents up to 0·1% and there is a gradual limit for amounts above this figure. Forming at collector contacts can be made to take place in both forward and reverse directions. C. A. HOGARTH

537.311.33 : 535.371

6967. Electron mobility and luminescence efficiency in cadmium sulfide. L. GILDART AND A. W. EWALD. *Phys. Rev.*, **83**, 359–63 (*July* 15, 1951).

The mobility of the photoelectrons produced in CdS by pulsed ultraviolet and X-ray excitation has been determined through measurements of the incident radiation, the luminescence radiation and the initial rates of rise and decay of the photocurrent. The mobility value as well as the efficiencies of the excitation and radiative recombination processes for the two types of excitation are obtained directly from these measurements by means of a general analysis which is independent of the details of the photoelectric mechanism. The following approximate numerical results are obtained: The electron mobility is 30 cm²/volt-sec. 2% of the conduction electrons radiate red light quanta upon recombining. Each 0·5 Å X-ray quantum produces about 2 000 conduction electrons. A.

537.311.33 : 537.323 : 621.314.7

6968. A study of thermoelectric effects at the surfaces of transistor materials. J. W. GRANVILLE AND C. A. HOGARTH. *Proc. Phys. Soc., Lond. B*, **64**, 488–94 (*June*, 1951).

The surfaces of various specimens of Ge and PbS have been explored with a whisker contact, and the character of the conduction mechanism in relatively small regions examined by the polarity of (*a*) the photo-voltaic effect, (*b*) the rectification, and (*c*) the thermoelectric effect. Methods (*a*) and (*b*) give results characteristic of the bulk material as determined by Hall effect measurements, whereas method (*c*) only gives results consistent with (*a*) and (*b*) for uncontaminated cleaved surfaces or for surfaces which have been etched after polishing. For polished surfaces anomalous effects are obtained and point to the existence of a layer on the surface of character different from that of the bulk semiconductor. A.

537.311.33 : 539.185

6969. The effect of fast neutron bombardment on the electrical properties of germanium. J. W. CLELAND, J. H. CRAWFORD, JR, K. LARK-HOROVITZ, J. C. PIGG AND F. W. YOUNG, JR. *Phys. Rev.*, **83**, 312–19 (*July* 15, 1951).

Lattice disorder in bulk Ge produced by collisions of fast neutrons with lattice atoms introduces a net excess of electron traps or acceptor states, which appear to have an energy distribution in the forbidden band. Bombardment of *n*-type Ge causes the conductivity to decrease, initially at a uniform rate, to a minimum value and then to increase; initially about 3·2 conduction electrons are removed per incident fast neutron. The minimum value of the conductivity is higher than the value calculated assuming complete homogeneity and thermal equilibrium. Hall effect measurements prove that after the minimum is passed the material has been converted to *p*-type by fast neutron bombardment. The conductivity of *p*-type Ge increases with bombardment. The rate of increase decreases monotonically indicating an approach to saturation. The initial rate of carrier introduction in *p*-type Ge appears to be temperature-dependent, being greater at higher temperatures (~ 0·8 carrier per incident neutron at 30°C), and smaller than the rate of carrier removal for *n*-type Ge which is apparently temperature-independent in the temperature range investigated (−79°C to 45°C). The effect of lattice disordering on the electrical properties of Ge may be removed by careful vacuum annealing at 450°C while a portion of this effect readily anneals at room temperature. A.

537.312.5

6970. Limits of performance of photoresistors (photoconductors). H. MÜSER. *Z. Phys.*, **129** (*No.* 5) 504–16 (1951) *In German.*

The limit of efficiency in photoconductors is due to background noise in the semiconductor. This limit cannot be extended by the use of narrow bandwidth amplification and other methods. The background noise consists of two parts, namely of the Nyquist noise and of that noise which is due to the statistical variations in the number of the charge carriers; the former is unimportant in photoconductors. The optimum effect in a photoconductor is reached when its volume is a practical minimum. The effectiveness decreases exponentially with increasing limit wavelength. A PbS photoconductor of $0{\cdot}25\ mm^2$ area and 5 μ thickness, with an i.r. threshold at $2{\cdot}7\ \mu$, can detect no less than $3{\cdot}5\times10^{-11}$ W. This is in contrast to a previous theory which predicted a value about 10^3 times smaller. W. SUMMER

537.312.5

6971. Electron multipliers. N. SCHAETTI. *Z. angew. Math. Phys.*, **2**, 123–58 (*May*, 1951) *In German.*

The theory and development of the electron multiplier during the last 15 years is reviewed and the most recent publications (80 references) are included and digested. The various types of sensitive layers and different shapes of dynodes are discussed. The arrangements of the dynodes of most electron multipliers are illustrated. The contents of the paper are classified thus: secondary electron emission; the production of layers of high secondary emission; the electron multiplier; the photomultiplier; applications of electron multipliers. W. SUMMER

537.312.5

6972. Photoconductivity in the elements. T. S. MOSS. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 590–1 (*June*, 1951).

Optical and thermal activation energies of the following elements are compared: Te, P, I, As, B, Se (red), S, C (diamond), Si, Ge. They are found to agree closely. For Ge, Si and diamond a specific relation $En^4 = \text{const.}$ is found with the refractive index, where the constant lies within $\pm8\%$ of 174 (the same relation holds for SiC).

537.312.5

6973. Energy distribution of external photoelectrons from *F*-centers in RbI. L. APKER AND E. TAFT. *Phys. Rev.*, **82**, 814–19 (*June* 15, 1951).

Energy distributions of the external photoelectrons from *F*-centres in RbI were determined by retarding-potential techniques. Precautions were taken to secure electrically uniform surfaces. The photoelectrons then emerged in two separable groups. The first, termed the *f*-group, was composed of relatively fast electrons that were attributed to direct photon ionization of *F*-centres. Photoelectron energies were distributed in a band, roughly Gaussian in form, that was treated according to a theory given by Herring. The Franck–Condon principle was taken into account; scattering of excited electrons was neglected. The second group of photoelectrons, termed the *s*-group, was comparatively slow. The energy distribution had an unusual form and peaked at the surprisingly low value of 0·3 or 0·4 eV, independent of $h\nu$. Exciton-enhanced emission was almost entirely of this type. Three factors that may influence the *s*-type distribution are mentioned: Hebb's calculations indicate that lattice scattering of exciton-induced emission may be important because of the relatively large depth of origin of these photoelectrons. As suggested by Seitz, degradation of exciton energy prior to *F*-centre stimulation may be involved. Finally, some of the photoelectrons in the *s*-group may arise in other types of centres. A.

537.312.5–15

6974. Photoconductivity in the infra-red region of the spectrum. I. The preparation and properties of photoconductive films of lead telluride. O. SIMPSON AND G. B. B. M. SUTHERLAND. **II. The mechanism of photoconductivity in lead telluride.** O. SIMPSON. *Philos. Trans. A*, **243** (*No.* 872) 547–84 (1951).

In Pt I the method of preparation of photoconductive films of Pb telluride is described. Details are given of the construction of cells suitable for i.r. detection in spectroscopic applications. Pb telluride is not photosensitive at room temperature, but is strongly photoconductive at temperatures in the region of −190°c. The conductivity of Pb telluride as a function of the applied voltage and the wavelength and intensity of illumination have been investigated for 7 films of widely different conductivity at liquid-air temperature. The application of the photoconductive effect to i.r. detection is discussed, and attention is drawn to the effect of any background of thermal radiation on the performance of a cooled photoconductor.

Pt II describes a method by which thin semiconducting films of nearly stoichiometric Pb telluride can be prepared by evaporation, in a sequence with increasing impurity of Pb. The conductivity and i.r. photoconductivity of the specimens have been investigated as a function of temperature and of Pb impurity. It is found that the magnitude of the photo-effect is a function of the dark conductivity, and depends only on the quantity of excess Pb. The absorption of O at room temperature is equivalent to the removal of excess Pb; the presence of O is not a requirement for the appearance of photoconductivity. These observations are used to draw conclusions concerning the mechanism of the photoconductivity. It is shown that all the phenomena can be explained by a single lattice model, without recourse to internal potential barriers or inhomogeneities in the composition of the samples. A.

537.312.5 : 535.343.2

Photoconductivity of rutile. *See Abstr.* 6855

537.312.5 : 535.371

Comparative study of photoconductivity and luminescence. *See Abstr.* 6886

537.312.5 : 537.32 : 538.632

6975. Electrical properties of selenium. I. Single crystals. H. W. HENKELS. *J. Appl. Phys.*, **22**, 916–25 (*July*, 1951).

Crystals of hexagonal Se have been grown in a melt. Their microstructures have been compared with those arising in vapour crystals. The dark resistivity has been studied as a function of axis orientation, tem-

perature, field and time of application of a field. The thermoelectric power has been measured and attempts made to measure Hall effect. The nature of the acceptor levels has been discussed, the approximate hole densities and mobilities have been determined, and values of the activation energies obtained. The field effects have been discussed and the phenomenon of an apparent semipermanent polarization occurring at quite low fields has been noted. A.

537.312.5 : 621.3.011.4 : 621.314.634

6976. Recovery of selenium rectifiers after a voltage pulse in the blocking direction. K. LEHOVEC. *J. Appl. Phys.*, **22**, 934–9 (*July*, 1951).

The capacitance of Se rectifiers which have been subjected to a voltage pulse in the blocking direction is found to be temporarily decreased after the pulse has ceased. The recovery of the changed capacity to its original value is investigated as a function of pulse height, pulse duration and temperature. The speed of the recovery can be greatly increased by illumination (through a transparent electrode) with light of the same spectral range which is effective in causing the photo-effect in Se photovoltaic cells. This is an indication that the phenomenon is of electronic and not of ionic nature. As an explanation it is proposed that an electric pulse in blocking direction removes electrons from elevated energy states in the electrode-Se boundary. Recovery occurs because electrons are returned to the elevated energy states by thermal agitation and also by photoelectric effect if the Se is illuminated. A.

537.312.5 : 621.383.4

6977. Characteristics and properties of lead sulphide photoresistances. B. T. KOLOMIETS. *J. Tech. Phys., USSR*, **21**, 1–11 (*Jan.*, 1951) *In Russian.*

Sensitivity in amp/watt is proportional to p.d. applied to photo-resistance. Dark current is maintained at 100–150 μA. Sensitivity is then 0·1–0·15 A/W and independent of internal resistance. This sensitivity cannot be regarded as constant and in some applications is limited by the noise-level admissible. The method of characterizing sensitivity by $(\Delta R/R)$ is independent of voltage. The type FS-A1 investigated has about 11% sensitivity at 100 lux. The V/W sensitivity was determined in steady conditions, i.e. without modulation, when, with a load equal to internal resist. (90 000 Ω) and 10 V applied, the voltage variation was 0·3 V, corresponding to 3 000 V/W. The sensitivity increase at low temperatures was confirmed. Photocurrent maximum is at −40°C, but there is a dispersion of the maxima for various specimens as high as 10–20°C. Relative variation of resistance at 170°C is almost 100%. Ratio between dark and photo-resistance increases 165× at low temps. The spectral sensitivity curve retains the same character for specimens of widely varying resistance ratings and frequency characteristics, but the same thickness of photo-sensitive layer. With decreasing layer thickness the max. of spectral distribution shifts towards shorter wavelengths and vice versa. The relation photocurrent/illumination is non-linear; highest sensitivity is for low illuminations. Relative variation of resistance per lux: for 1 lux, 3·34%; 5 lux, 1·2%; 10 lux, 0·77%; 20 lux, 0·486%; 200 lux, 0·1%. The temperature relation has hysteresis. Sensitivit loss between 25–50°C: 1·48–176% per deg. c. Th lower the sensitivity, the less is it influenced b frequency. Among 200 specimens tested, poor one had an output reduction of 10·5 db, i.e. to 1/3·5 c initial one, good ones only 0·1 db, or 11% outpu reduction. Noises investigated with band-pas amplifier of 15 000 c/s bandwidth. Average nois level at 6 V, 30–40 μV. Better specimens, 1–1·5 μ per V appl. p.d. B. F. KRAU

537.312.6

6978. The electrodynamic potential in the generalize phenomenological theory of superconductivity. F BECK. *Z. Phys.*, **129** (*No.* 3) 246–74 (1951) *In Germa*

By introducing into the generalized non-linea theory v. Laue's electrodynamic potential [Abst 2466 (1950)], it is possible to give the uniquene proof for the stationary field. The expression for th potential also gives the force density and the angula momentum of the generalized theory [Abstr. 650 (1950)]. H. LONDO

537.312.6

6979. The critical magnetic fields of aluminium, cadmium, gallium and zinc. B. B. GOODMAN AN E. MENDOZA. *Phil. Mag.*, **42**, 594–602 (*June*, 1951).

The low temperatures produced by the adiabati demagnetization of a paramagnetic salt have bee used to cool specimens of Al, Cd, Ga and Zn, an their critical fields have been measured down t 0·1°K. The magnetic measurements on the meta and the salt were made independently and the exper mental arrangement had the further advantage tha the quality of the thermal contact between the meta and the salt could be studied. The results could b accurately expressed by relations of the form $H_c =$ $H_0[1 - (T/T_c)]^2$ values of H_0 and T_c for each meta are tabulated. A

537.3

6980. The motion and precipitation of suspensoids i divergent electric fields. H. A. POHL. *J. Appl. Phys* **22**, 869–71 (*July*, 1951).

The motion of suspensoid particles relative t that of the solvent resulting from polarization force produced by an inhomogeneous electric field defined as "dielectrophoresis." It is analogous t the related phenomenon of electrophoresis, i which motion of suspensoid particles is produced b the action of an electrostatic field on the charge particles. From a consideration of theoretical ca culations and from experimental observations it concluded that the phenomena of "dielectrophoresis and "dielectro-precipitation" can be observed unde rather ideal conditions, though it is ordinarily ofte difficult to do so because of the presence of the mo easily produced electrophoresis or ion-type migratio of charged particles. The usefulness of dielectr phoresis (and/or electrophoresis) for removin suspended solid particles from polymer solution during analysis is described. A

537.365 : 534.39 : 541.18

6981. On electrical effects due to sound waves i colloidal suspensions. J. A. ENDERBY. *Proc. Ro Soc. A*, **207**, 329–42 (*July* 6, 1951).

It is shown that, for charged colloidal particles

differences of potential arise between different points in the wave train. A general method is given for obtaining the amplitude of the potential difference in the case when the thickness of the double-layer surrounding the particles is small compared with the particle radius, as a power series in the zeta-potential and the leading term in this series is evaluated, so that the results will be adequate for zeta-potentials which are not too large. An exact expression is obtained for the case when the thickness of the double-layer is very much greater than the particle radius but still much less than the mean separation. An attempt is also made to estimate the effect for intermediate values of the double-layer thickness. The amplitude of the potential difference decreases with increasing concentration of electrolyte and, when measured between points a half-wavelength apart, is substantially independent of the frequency of the sound waves, except at very high frequencies. The results are compared with the experimental data. A.

537.39 : 621.385

6982. The measurement of fluctuation noise by diode and anode-bend voltmeters. R. E. Burgess. *Proc. Phys. Soc., Lond. B*, **64**, 508–18 (*June*, 1951).

The response of a diode voltmeter to a c.w. sine-wave signal and to noise is analysed for three typical diode characteristics: discontinuous linear, discontinuous parabolic and exponential. In the first type the indication is proportional to the r.m.s. value of the input voltage but the constant of proportionality is different for noise and for c.w. and depends upon the ratio of the load resistance to diode resistance. For small input signals the curvature of the diode characteristic is important and the voltmeter tends to a square-law behaviour with the result that c.w., noise or a mixture of c.w. and noise can all be measured in terms of a single calibration. The input conductance of a diode voltmeter is in general greater for noise than for c.w. It can be very much greater in practical conditions and this represents a possible source of error in the measurement of noise. The response of the anode-bend voltmeter to c.w. and to noise is considered for a discontinuous parabolic and for an exponential characteristic. The departure of the c.w. calibration from a square law and the difference between c.w. and noise calibrations are evaluated in terms of the characteristics. A.

ELECTRIC DISCHARGES 537.52

537.521

6983. The distribution of electron energies in a discharge constricted by its self-magnetic field. J. E. Allen. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 587–9 (*June*, 1951).

An equation of Davydov [*Phys. Z. Sowjet.*, **12**, 269 (1937)] is applied to the positive column of a high current arc for the case of negligible radial electric field, and assuming constant mean free path. The distribution departs substantially from the Maxwellian, the proportion of fast electrons being smaller. Maxwellian distribution will be approached as the degree of ionization rises, to make mutual interaction between electrons not negligible.

537.521 : 537.533.7

6984. The electron energy distribution in helium. S. H. Dunlop and K. G. Emeleus. *Brit. J. Appl. Phys.*, **2**, 163 (*June*, 1951).

Smit's data for the energy distribution amongst electrons drifting through He when the ratio of the electric field to gas pressure is small have been extended to higher values of electron energy by development of his formulae. Attention is called to the possible inaccuracy of some collision data on which the calculations are based. A.

537.523

6985. Theory of the development of the channel of the gas discharge. S. I. Drabkina. *J. Exp. Theor. Phys.*, **21**, 473–83 (*April*, 1951) *In Russian.*

The theory is based on the hydrodynamical impulse relations. The fundamental equations used are the continuity equation, Euler's equation of movement and the adiabatic equation, the boundary conditions being supplied by the continuity condition of the flow of plasma, momentum and energy at the boundary of the excited region, i.e. the front of the impulse wave. The solutions have "self-modelling" character, i.e. the gas parameters ρ/ρ_f, p/p_f and v/v_f depend on space co-ordinate and time only through a dimensionless factor $\xi = r/R$ (index f refers to wave front). A strict solution of the system of fundamental equations being obviously impossible, an attempt is made to consider the real state of the gas and the retarded energy influx on Sedov's scheme [*Dokl. Akad. Nauk, SSSR*, **47**, 94 (1945)]. A tentative equation of state, combined with Saha's equation, leads to a comparatively simple relation for the state of a once- and twice- ionized plasma, suitable for experimental verification. The gradual energy influx may also be considered. The relations determining the dimensions and expansion rate of the spark channel are derived from the assumption of a mass of excited gas inside a cylindrical "envelope" at the temperature 10^4K. The calculations show that owing to the low gas density this mass of gas must be completely ionized and thus actually constitute a conducting channel. This supposition is of great heuristic value, because all the quantities required may actually be found in a comparatively simple way. The phenomenon of the envelope of the discharge channel is investigated in great detail and found to constitute the well-defined separation between the rarefied gas in the channel and the gas of approximately normal density without. B. F. Kraus

537.523

6986. Oscillographic investigation of the spark discharge. I. S. Abramson and N. M. Gegechkori. *J. Exp. Theor. Phys.*, **21**, 484–92 (*April*, 1951) *In Russian.*

Preliminary investigations of the dilatation of the spark channel showed that the dilatation rate of the channel and its diameter depend in the main on the electrical parameters in the discharge circuit and on the energy liberated in the discharge channel. Drabkina's paper (preceding Abstr.) suggested a method of calculating the channel dilatation from the

energy influx. For this purpose oscillograms of current and voltage in the spark gap were taken. There are three stages in the voltage curve of a spark discharge, viz. an initial steep drop from the voltage applied to the electrodes, lasting about 10^{-8} sec; smoother transition to the sparking voltage proper, and the arc discharge stage. The second stage is insufficiently known and was mainly investigated. Relations between energy influx into the discharge gap and the circuit parameters L, C, V were found.

B. F. KRAUS

537.523

6987. Experimental investigation of the channel of the spark discharge. N. M. Gegechkori. *J. Exp. Theor. Phys.*, **21**, 493–506 (*April*, 1951) *In Russian.*

Results of an experimental investigation of the development of the channel of the spark discharge by rotating mirror photography and Toepler's half-shadow analysis are compared with the hydrodynamical theory of the channel development. The agreement is satisfactory, considering the approximative character and simplifying assumptions of the theory. Results show convincingly that the dilatation rate of the channel is intimately connected with the propagation velocity of the shock wave and the influx velocity of the energy into the discharge region, and also with the parameters of the discharge circuit. This proves the appropriateness of the hydrodynamical considerations to the purpose. The pictures obtained are striking as "classical" Mach pictures. It is also conclusively proved that photo-ionization plays, if any, only a very subordinate role. Further observations were made on the character of the envelope of the discharge. Some criticism is levelled at certain details of the Drabkina theory (preceding two Abstr.) and the difficulty of evaluating the irradiated energy is pointed out (due to the fact that the radiation of the spark is very far from having black-body character).

B. F. KRAUS

537.523

6988. Dilatation of the channel of the impulse discharge in inert gases. K. S. Vulfson and I. Sh. Libin. *J. Exp. Theor. Phys.*, **21**, 510–13 (*April*, 1951) *In Russian.*

Measurement of the dilatation rate of the channel of the impulse discharge in A, Kr, Xe by the rotating mirror method. Luminescence of the gas is established as an effect of the reflected shock wave. The case of the formation of two independent channels is also shown and described. These investigations are interesting for the illumination engineer because they enable the dimensions of the luminescent gas volume and approximate temperature and pressure of the process to be determined. The peculiar phenomena in the channel of the impulse discharge may furthermore lead to an understanding of the intrinsic mechanism of the whole phenomenon as such, distinguished as it is by an exceedingly high energy concentration. A simple empirical formula represents the channel diameter measured 5–8 μsec after the inception of the discharge, viz. $d = BV(U/pM)$, where U capacitor potential in kV, M molecular weight of gas, p gas pressure (atm.). Constant $B = 28$ for $C = 1{\cdot}09$ μF; $L = 0{\cdot}6$ μH.

B. F. KRAUS

537.523.5 : 621.3.066.6 : 621.316.5.064.2

6989. Arcing at electrical contacts on closure I. Dependence upon surface conditions and circuit parameters. L. H. Germer. *J. Appl. Phys.*, **22** 955–64 (*July*, 1951).

In a low-voltage circuit the occurrence of an arc between approaching electrodes is dependent upon the nature of the surfaces and upon the circuit inductance. For C surfaces, or noble metal surfaces which have been "activated" by operation in various organic vapours resulting in a carbonaceous layer the limiting circuit inductance is somewhat above 10^{-3} H, which is much higher than the limiting inductance for clean noble metal surfaces. This activation by organic vapours occurs for noble metals only and for certain vapours; for example, benzene derivatives. In the case of Ag and benzene vapour it has been shown that the activation is due to adsorption of benzene on to a greasy surface layer and its decomposition there by the heat of subsequent closures. A metal surface, which has been activated by organic vapours, remains active indefinitely if there is no arcing at the surfaces; but with continued operation and accompanying arcing, the activating material is burned away and the surface returns to the inactive condition if no activating vapour is supplied. Arc voltages, which are independent of current and of ambient gas, as far as tested, have been measured for a number of metals and for C; the arc voltage for C is quite erratic in the range between 20 and 30 V, but for each of a number of metals the arc voltage is steady. Arcing at noble metal surfaces, similar to that induced by carbonaceous material from organic vapours, can be produced also by insulating particles or insulating films. The active condition gradually disappears with continued arcing, unless there is a steady supply of insulating material to the surface. The minimum arc current has been measured to be 0·6 A for active Ag and for C, and 0·03 A for inactive Ag. These are the currents at which an established arc is extinguished.

A.

537.525

6990. Theory of losses. A. A. Vlasov and I. P. Bazarov. *J. Exp. Theor. Phys., USSR*, **20**, 1098–108 (*Dec.*, 1950) *In Russian.*

In furtherance of former work a non-linear theory of the periodic distribution of electrons in a plasma is given, i.e. of the losses enabling the amplitude A of the potential oscillations in a stratified positive column to be determined. The mathematical achievement is the solution of the fundamental non-linear equation leading to the determination of the amplitudes of the partial harmonics of the solution which is periodic in time. The relation of these amplitudes to the fundamental discharge parameters, i.e. drift velocity, temperature and concentration of the electrons is also found. The consideration of the boundary effects leads to decreasing and increasing oscillator solutions. Damping coefficient and period as functions of the discharge parameters are also determined. This type of solution has a physical meaning as limiting case for vanishing field frequency, thus for time-periodical phenomena in discharge tubes. The calculation of the amplitudes shows not only qualitative, but also satisfactory quantitative

agreement with the experimental results for Hg vapour of Compton, Turner and McCurdy [*Phys. Rev.*, **24**, 597 (1924)] and Zaitsev, for Ne. B. F. KRAUS

537.525

6991. Microsecond transient currents in the pulsed Townsend discharge. J. A. HORNBECK. *Phys. Rev.*, **83**, 374–9 (*July* 15, 1951).

The transient current resulting from the release of a very short (0·1 μsec) pulse of photoelectrons at the cathode of a gas-filled tube has been observed experimentally. The current-time patterns agree quantitatively with theory within the limitations of the theory and experimental accuracy. The experiment provides a method for studying fundamental parameters and processes occurring in the noble gases; drift velocities of positive ions and electrons, identification of molecular ions, cross-section of formation of molecular ions, and the importance in the Townsend discharge of electron emission at the cathode caused by positive ion neutralization there. A.

537.525.6

6992. Luminous fronts in pulsed gas-discharges. R. G. FOWLER, J. S. GOLDSTEIN AND B. E. CLOTFELTER. *Phys. Rev.*, **82**, 879–82 (*June* 15, 1951).

Recent experiments in which an intense luminosity was observed in side tubes connected to an electrodeless discharge ring have been duplicated using a discharge with electrodes. It is concluded that a large part of the luminosity observed is the result of a moving front of disturbance rather than the decay of an ejected tongue of excited gas. Measurements made of the velocity of advance of this front and its dependence on gas parameters show that the front advances into the side tube with a speed proportional to the estimated velocity of sound in the hot gas of the main discharge. Intense continua accompany discrete spectra in the fronts, particularly in H, indicating that recombination may play a large part in producing the luminosity observed. A.

537.525.8

6993. Electron temperature vs. noise temperature in low pressure mercury-argon discharges. M. A. EASLEY AND W. W. MUMFORD. Letter in *J. Appl. Phys.*, **22**, 846–7 (*June*, 1951).

Summarizes earlier work on the relation between T_N (noise temp.) and Te (electron temp.) and quotes more recent data showing that for certain discharges $T_N \simeq Te$. The effect of discharge tube wall temp. is also discussed. J. D. CRAGGS

537.525.8 : 537.568

6994. Production of recombination spectra. K. G. EMELEÚS AND G. A. SMITH. Letter in *Proc. Phys. Soc., Lond. B*, **64**, 426–7 (*May*, 1951).

Discusses an expt. by Freeman [*Z. Phys.*, **59**, 635 (1930)] on the diffusion of an a.c. discharge into the side arm of an exptl. tube. Certain objections to Freeman's interpretations are enumerated and illustrated by reference to new work with similar tubes and a variety of discharge conditions. J. D. CRAGGS

537.525.8

6995. Electron removal in mercury afterglows. P. DANDURAND AND R. B. HOLT. *Phys. Rev.*, **82**, 868–73 (*June* 15, 1951).

Observations of the electron density, visible and near u.v. light intensity, and spectrum associated with a 2 800 Mc/s pulsed electrodeless discharge through Hg vapour have been made. The results indicate ambipolar diffusion as the principal mechanism of electron removal at low pressure, with attachment becoming increasingly important at higher pressure. The data also yield a considerable amount of information regarding electron temperatures, recombination coefficient, and other parameters necessary to a detailed description of the processes taking place in the discharge. A.

537.525.8

6996. Electron removal in argon afterglows. A. REDFIELD AND R. B. HOLT. *Phys. Rev.*, **82**, 874–6 (*June* 15, 1951).

Ambipolar diffusion and recombination occurring in A after the cut-off of a pulsed microwave discharge have been studied. The electron density and spectroscopic data obtained indicated that ambipolar diffusion is operative at low pressures, supplemented by recombination which is characterized by a relatively low recombination coefficient. At high pressures, electron removal is principally by recombination which is characterized by a relatively high value of recombination coefficient. A.

537.527.4

6997. Failure of Paschen's law and spark mechanism at high pressure. F. LLEWELLYN JONES AND C. G. MORGAN. Letter in *Phys. Rev.*, **82**, 970–1 (*June* 15, 1951).

The failure of Paschen's law at high gas pressures p in short gaps has been found to be due to a cathode-dependent mechanism [see Abstr. 1083 (1951)]. It is shown experimentally that pre-breakdown electron emission from the cathode follows a field law, which makes the emission depend on the field F and not on F/p; thus accounting for failure of Paschen's law. This emission is enhanced by impact of positive ions on the cathode, leading to an apparent increase in the γ secondary coefficient. A.

537.529 : 621.3.015.533

6998. "Heat developed" and "powder" Lichtenberg figures and the ionization of dielectric surfaces produced by electrical impulses. A. M. THOMAS. *Brit. J. Appl. Phys.*, **2**, 98–109 (*April*, 1951).

A brief outline of the characteristics of Lichtenberg figures is given. Some experiments on "heat developed" and "powder" figures are reported. With regard to the former it is shown that the effect is restricted to certain kinds of solid dielectrics and associated with the state of the surface; an explanation of the mode of their formation is suggested. The effect of repetition of impulses of alternating polarity is investigated by means of "powder" figures. It is shown that the effect of a discharge of given polarity is not neutralized or cancelled by a succeeding discharge of the opposite polarity. This leads to the conclusion that local electrical or mechanical failure in the surface may occur owing to the chance that positively and negatively charged particles will in the course of time be brought very close together. A difference between the Lichtenberg figures produced by negative impulses of short and long wave front and tail is demonstrated; an explanation based on the

theory of spark discharge is given. The electrostatic charges produced on the dielectric surface by single and multiple impulses are measured. The results indicate that in order to produce the charge, electron emission from the dielectric surface, when this is the cathode, is necessary; this is evidence that formation of a cathode spot on the dielectric surface is possible, and may be capable of triggering the process which results in failure of the dielectric. A.

X-RAYS 537.531

537.531 : 534.5

6999. On the resultant effect of X-ray transmission through many equivalent layers. H. KULENKAMPFF. *Z. angew. Phys.*, **3** (*No.* 3–4) 118–22 (1951) *In German.*

Discusses X-ray transmission through a pile of layers with periodic structure and with random phase-relations. A parallel is drawn with the superposition of sounds from a number of similar musical instruments. A. R. STOKES

537.531 : 535.33.07

7000. The use of the Geiger–Müller counter X-ray spectrometer in an X-ray laboratory, with special reference to automatic recording. C. WAINWRIGHT. *Brit. J. Appl. Phys.*, **2**, 157–62 (*June*, 1951).

The advantages and limitations of G.M. counter techniques in a laboratory applying X-ray methods to a variety of problems are discussed and some simple examples are described. These illustrate the convenience of its use in obtaining semi-quantitative results very rapidly and in following the effects of various treatments. The accuracy of the method is considered in relation to the statistical effects associated with the operation of the G.M. counter and the influence of damping in the recording system. A.

537.531 : 535.343

7001. The *K*-absorption limit of antimony. N. NILSSON. *Ark. Fys.*, **3**, *Paper* 12, 167–9 (1951).

The *K*-absorption edge for Sb was determined by the Cauchois method, using as reference lines Te $K\alpha_1\alpha_2$ and β_1. The value obtained is $405{\cdot}88 \pm 0{\cdot}08$ X.U. The width of the edge is $0{\cdot}5 \pm 0{\cdot}1$ X.U. The value obtained for the wavelength of Sb $K\alpha_1$ is $469{\cdot}372$ X.U., and that for Ag $K\alpha_1$ is $558{\cdot}252$ X.U. J. THEWLIS

537.531 : 535.82

7002. An X-ray microscope using mirrors of adjustable curvature. C. M. LUCHT AND D. HARKER. *Rev. Sci. Instrum.*, **22**, 392–5 (*June*, 1951).

The mirrors are thin optical flats which are mechanically bent to obtain the radius of curvature necessary to focus the image. The adjustable curvature increases the flexibility of the microscope and the ease of focusing the image. The difficulties of grinding and polishing concave cylindrical surfaces are avoided. The degree of smoothness of reflecting surfaces was studied, and the anelastic properties of various mirror materials were investigated to find a material suitable for bending. Highly polished tungsten carbide was found to be an excellent mirror material and does not require an evaporated surface coating of high density metal. A.

537.531 : 621.386

7003. Centring the cathode in a demountable X-ra tube. R. FOURET. *C.R. Acad. Sci., Paris*, **232**, 1651– (*April* 30, 1951) *In French.*

Visual adjustment of the cathode relative to th anode of this demountable X-ray tube is not possible either before or after the vacuum is made. When th cathode is centred, the electrical capacity betwee anode and cathode is minimum. Cathode-anod capacity measurement is made on an off-balance a.c bridge. A curve of galvanometer deflection agains distance off centre of the cathode is symmetrical, an has a distinct minimum. In practice, there are tw positions of the cathode for which equal galvanomete deflections are obtained; the centre cathode positio is then set midway between these limits. D. V. MABE

CATHODE RAYS . POSITIVE RAYS 537.533/.53

537.533 : 621.384.6

7004. On the radio-frequency requirements of hig energy electron synchrotrons. T. R. KAISER. *Proc Phys. Soc., Lond. B*, **64**, 502–7 (*June*, 1951).

A theory of the transition between betatron an synchrotron acceleration is specifically applied to hig energy electron synchrotrons. The results are use to calculate the r.f. voltage required for two suc machines at present being constructed. It is show that with suitable choice of its initial rate of rise, th r.f. voltage need rise only to a peak value which is nc greatly in excess of the voltage per revolution require to maintain an electron on the synchrotron equili brium orbit. A

537.533 : 621.384.6

7005. Operation of a six-Mev linear electro accelerator. G. E. BECKER AND D. A. CASWELL *Rev. Sci. Instrum.*, **22**, 402–5 (*June*, 1951).

The accelerator is of the travelling-wave type, 14 f in length. A single magnetron wavelength $10{\cdot}5$ cr is used as a power source, with a peak power outpu of $0{\cdot}9$ MW. Electrons are injected at a velocit $v = c/2$. Approximately 1/20 of the injected electron reach the target end of the accelerator, with energie falling in a 1 MeV range near 6 MeV. The averag current obtained is $0{\cdot}05$ μA. With an electron puls length of $0{\cdot}8$ μsec and a pulse repetition rate o 60 per sec, this corresponds to a peak current of th order of 1 mA. A

537.533.7

7006. The trajectories of charged particles slightl deviated from their initial direction by an electrostati field. B. M. RABIN AND A. M. STRASHKEVICH *J. Tech. Phys., USSR*, **20**, 1232–40 (*Oct.*, 1950) *In Russian.*

The time-independent differential equations of suc trajectories are set up and are shown to lead to th known results when applied to a lens with rotationa symmetry or a cylindrical lens. Applied to a trans gradient system, they reduce to a form which may b solved by quadrature. A numerical example is worke and compared, inter alia, with the formulae o Hutter [Abstr. 3553 (1947)]. J. C. E. JENNING

537.533.72

7007. Conditions for the correction of astigmatism and of curvature of field in [axially symmetric electrostatic] electron lenses. P. P. KASYANKOV. *J. Tech. Phys., USSR*, **20**, 1426–34 (*Dec.*, 1950) *In Russian.*

Starting from the differential ray equation, necessary and sufficient conditions are formulated for the correction of astigmatism, meridional and sagittal curvature of field. These conditions are expressed in terms of explicit functions of the axial potential and its derivatives, and have to be satisfied throughout the lens. J. C. E. JENNINGS

537.533.72

7008. The aberrations of magnetic electron lenses due to asymmetries. P. A. STURROCK. *Philos. Trans. A*, **243** (*No.* 868) 387–429 (1951).

Electron microscope objective lenses are considered; the asymmetries are due to misalignment and to distortion of the pole pieces, not to inhomogeneity of the iron, the surfaces of which are regarded as magnetic equipotentials. Each pole piece is assumed to be bounded by a semi-infinite cylinder, the surfaces of which are subjected to perturbations which are developed as Fourier series in the azimuthal angle, corresponding expressions being obtained for the potential field in the presence of these perturbations and of non-skew misalignments. The primary aberrations are derived by a variational method. Distortions of period π (elliptic distortions) lead only to axial astigmatism (i.e. astigmatic focusing of an object point on the axis); distortions of higher order, which are less important, are not discussed. Misalignment leads to axial coma, which varies linearly, and to axial astigmatism, which varies quadratically with the misalignment. Examples are worked with a lens having a pole separation = bore diameter ($2a$), (1) as an immersion lens with a focal length = $4a/3$, and (2) as a weak lens, the magnification being great in each case. The potential field is found by a relaxation method, some difficulty being experienced at the sharp edges formed by the surfaces $r = a$ and $z = \pm a$ [cf. also the discussion Sturrock–Le Poole, *Proceedings of the Conference on Electron Microscopy, Delft, July* 1949, p. 93]. Referring the aberration to the object, it is found for case (1) that the variation δa ($= a_{max} - a_{min}$) must be $< \frac{1}{4}\delta f$ (δf = permissible longitudinal astigmatism); the astigmatism is due almost entirely to the image-side pole piece. In case (2) if the major axes of the ellipses are $\|$, $\delta f/f \simeq 4\delta a/a$, whilst, if they are $\perp$, $\delta f/f \simeq 4(\delta a/a)(f/a)^{\frac{1}{2}}$. When the major axes are $\|$, the ellipticity of the equipotentials near the axis $\simeq$ that of the pole piece bore, at least in the present example. J. C. E. JENNINGS

537.533.72

7009. Computation of the electron optical focusing of three typical strong magnetic lenses and their relation with the usual lens equation. W. GLASER AND F. LENZ. *Ann. Phys., Lpz.*, **9** (*No.* 1) 19–28 (1951) *In German.*

$H_z = H_0[1 + (z/a)^2]^{-\mu}$ with $\mu = 1$, 3/2, 2 and ∞ [cf. Abstr. 2451 (1944) and 1103 (1951)]. Graphs show object and image positions, focal lengths, positions of "osculating foci" [see Abstr. 2731 (1951)] *v.* magnification, with lens strength as parameter. It is pointed out that the circular conductor (i.e. $\mu = 3/2$), like the systems with $\mu = 2$ and ∞, is non-Newtonian. The (paraxial) ray equation was solved numerically except for $\mu = 1$. J. C. E. JENNINGS

537.533.72

7010. On the significance of the concepts "focal point" and "focal distance" in electron optics, and on strong electron lenses with Newtonian image equations. W. GLASER AND O. BERGMANN. *Z. angew. Math. Phys.*, **2** (*No.* 3) 159–88 (1951) *In German.*

For earlier report see Abstr. 2731 (1951). It is shown that the usual definition of focal distance is inapplicable in strong electron lenses and is more complicated than in light optics. The correct expressions are approximated to fourth-order terms, in the neighbourhood of two conjugate points by the "Newtonian equation for the image function." If the choice of conjugate points does not influence the resultant cardinal points, the latter are identical with the usual parameters. Strong fields are then studied and a technique for approximating the empirically determined field by a "Newtonian" field (one which obeys the usual expressions) is given. Finally, experimental methods for determining the cardinal points for the approximate fields are discussed. A. H. W. BECK

537.533.72

7011. The rotating beam method for investigating electron lenses. D. E. GEORGE, R. G. E. HUTTER AND M. COOPERSTEIN. *Sylv. Techn.*, **4**, 41–3 (*April*, 1951).

If a narrow electron beam is scanned elliptically and the lens under test is of such a strength that the paraxial image of the centre of deflection is on the fluorescent screen, then spherical aberration will produce an approximate figure of 8. This will be unsymmetrically distorted if the alignment is faulty or if the lens lacks axial symmetry. In the absence of these 2 defects, circular scanning will give a circular trace whose radius is the transverse spherical aberration. [Aberration of the scanning system is not discussed]. J. C. E. JENNINGS

537.533.72 : 621.385.833

7012. Space-charge effects in h.f.-modulated electron beams. J. LABUS. *Ann. Phys., Lpz.*, **9** (*No.* 1) 6–18 (1951) *In German.*

Studies, after Hahn, a plasma consisting of equal densities of ions and electrons. In the h.f. case only the electrons move, giving rise to dynamic space-charge effects. Differential equations for the motion can be set up with space-independent coefficients when the static space charge vanishes. A perturbation solution is developed with the ratio of space charge to e as parameter. A. H. W. BECK (R)

537.533.72 : 621.385.833

7013. Zonal correction of spherical aberration in magnetic lenses. G. NADEAU. *Atti Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **10**, 225–9 (*March*, 1951) *In French.*

Following the suggestion of Persico [Abstr. 4130 (1950)] the correcting action of dipole fields is considered. The *r-z* differential equation of non-skew rays has been numerically integrated, by a method which is described, for coaxial combinations of a circular conductor and 2 dipoles, respectively between object and conductor and between image

and conductor. Graphs are shown of the axial displacement of the marginal focus *v.* aperture angle, in the zone of correction, for 3 unsymmetrical combinations of dipole strengths and positions, and one value of the current, the magnification being close to unity; it is assumed that the 3 fields do not interfere. Each graph shows a maximum between 2 minima. If a displacement tolerance of 0·013 of the "focal length" (defined on the assumption that the combination is a thin lens) is allowed, the systems collect solid angles of 0·12 to 0·19 steradians, compared with 0·004 for the conductor without dipoles.

J. C. E. JENNINGS

537.533.72

7014. On the disposition of the diaphragms in helicoidal beta spectrometers. E. Persico. *Atti Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **10,** 344–8 (*May*, 1951) *In Italian.*

The two edges of the (annular) exit stop are often made to lie on a cone having its apex at the source. It is pointed out that a correction is necessary if the entrance stop is not very near to the source. The best position for the latter stop is indicated which allows the exit stop to be given the form most readily realized in practice. L. PINCHERLE

537.533.75

7015. The energy lost by fast electrons traversing foils (multiple scattering). W. Schultz. *Z. Phys.*, **129** (*No.* 5) 530–46 (1951) *In German.*

A method of Landau [*J. Phys., USSR*, **8,** 201 (1944)] is used to obtain an integro-differential equation for the slowed electrons. A Fourier transformation gives an integral representation of the distribution function which is solved by approximation. Comparison with measurements shows good agreement at 2·8 MeV, but at 4·7 MeV the experimental curves are considerably broader than the theoretical. The measurements exhibit the effect of the polarization of the scattering medium (Fermi correction) very clearly. A. H. W. BECK

537.533.8

7016. The characteristics of secondary emission. M. A. El-Sherbini. *Proc. Egyptian Acad. Sci.*, **5,** 52–63 (1949).

The problem of the reflection coefficient for very low energy electrons at a metal surface is discussed. The quantum theory of the effect is qualitatively discussed. An apparatus was constructed in which the target was a small sphere inside a much larger spherical collector. For Cu, the reflection coefficient was 0·075 for a net incidence energy of zero, 0·25 for 1 eV. For Mo, results of 0·075 at zero and 0·21 at 0·3 eV were obtained. A. H. W. BECK

537.533.8

7017. On the extraction of electrons from metals by neutral gas molecules with electro-negative properties. S. V. Ismaĭlov and A. M. Furman. *J. Exp. Theor. Phys., USSR*, **20** (*No.* 8) 729–33 (1950) *In Russian.*

It is shown that unexcited molecules of neutral gas can extract electrons from a metal. The number of electrons extracted by one molecule incident normally is calculated as a function of the polarization coeff. of the molecules, the work function of the metal and the distance of closest approach. E. P. GEORGE

537.533.

7018. Secondary emission from Ni, Mo, MgO an glass. G. Blankenfeld. *Ann. Phys., Lpz.*, **9** (*No.* 48–56 (1951) *In German.*

The variation of δ with primary energy and tem perature was studied. For Ni, Mo and glass δ i practically independent of T. For MgO δ decrease with increasing T, the rate of decrease diminishing a the primary energy increases. At room temperatur δ max $\simeq 4{\cdot}5$ at $V_p \simeq 800$ V. The results are dis cussed from the viewpoint of scattering by collisio with free electrons, whose density increases wit temperature. A. H. W. BEC

537.533.

7019. Silicone oil vapour and secondary electro emission. A. Lempicki and A. B. McFarlane Letter in *Nature, Lond.*, **167,** 813–14 (*May* 19, 1951)

It is found that the secondary electron emission c various surfaces *in vacuo* is diminished in a short tim of electron bombardment by the presence of thin oi films on them from the silicone oil diffusion pumps.

G. F. J. GARLIC

537.533.

7020. Energy-angle distribution of thin targe bremsstrahlung. L. I. Schiff. *Phys. Rev.*, **83,** 252– (*July* 15, 1951).

The differential bremsstrahlung cross-section o Bethe and Heitler is integrated over scattered electro angles to obtain an expression for the distribution in energy and angle of the radiation from fast electron in very thin targets. Screening is taken into accoun through the assumption of an atomic potentia $(Ze/r) \exp(-r/a)$, and the calculation is restricted t high energies and to small or moderate angles. Th result is the same as that of Sommerfeld for n screening, except that the argument of the logarithm now depends on angle as well as on energy. Integra tion of this expression over gamma-ray angle gives a analytic formula for the total intensity that is nowhere more than a few % higher than the Bethe–Heitle result calculated numerically on the basis of the Thomas–Fermi potential. A

537.533.9 : 537.312.5 : 621.383.42

7021. The electron voltaic effect. W. Ehrenberg C. S. Lang and R. West. Letter in *Proc. Phys. Soc., Lond. A*, **64,** 424 (*April*, 1951).

Photo-voltaic cells are found to be sensitive to electron bombardment. A gain of 500 was obtained with a Westinghouse Se cell bombarded with 50 kV electrons. J. A. FRANKS

537.534

7022. A rotating lithium target. E. Lampi. Note in *Rev. Sci. Instrum.*, **22,** 429 (*June*, 1951).

537.534.72

7023. Mass spectrometer resolution of ion pairs of similar *m/e*. D. V. Kniebes, S. Katz and R. B. Bernstein. Letter in *J. Chem. Phys.*, **19,** 654–5 (*May*, 1951).

Shows the limits of mass resolution obtainable with a Consolidated mass spectrometer, Model 21–103, with mass spectra for 12 pairs of ions.

T. G. PICKAVANCE

537.534.72

7024. Radiofrequency mass spectrometer. P. SCHISSEL. Letter in *J. Appl. Phys.*, **22**, 680 (*May*, 1951).

Proposes an apparatus in which ions oscillate in a parabolically distributed axial electrostatic field. An r.f. field is applied near the origin; ions whose oscillation period is an odd integral multiple of the r.f. period gain energy and are collected.

T. G. PICKAVANCE

537.534.74

7025. Elastic *d–p* scattering at 190 MeV. M. O. STERN AND A. L. BLOOM. Letter in *Phys. Rev.*, **83**, 178 (*July* 1, 1951).

C and polythene targets were used alternately and observed with stilbene crystals. Measured cross-sections agree with Chew's theoretical values [Abstr. 1176 (1949)] up to 110°. Above that angle the observed values are lower. F. R. HOLT

537.534.74

7026. Proton-proton scattering at 105 Mev and 75 Mev. R. W. BIRGE, U. E. KRUSE AND N. F. RAMSEY. *Phys. Rev.*, **83**, 274–80 (*July* 15, 1951).

The proton-proton differential scattering cross-section has been measured at 105 MeV and at 75 MeV by using the internal beam of the Harvard cyclotron. Scintillation counters detected the scattered and recoil protons in coincidence while the beam current was monitored by measuring the absolute activity of C^{11} formed in the polyethylene scattering foil. The cross-section as a function of angle in the centre-of-mass system appears to be isotropic within statistical deviation. It has the values $5{\cdot}4\times10^{-27}$ cm^2 and $6{\cdot}6\times10^{-27}$ cm^2 at 105 MeV and 75 MeV respectively, with an estimated error of 20%. A.

537.534.75

7027. The range of protons from the reaction $^{14}N(n,p)^{14}C$ in Ilford C2 photographic emulsion. F. A. EL-BEDEWI. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 584–5 (*June*, 1951).

Two plates were exposed for 90 minutes to a flux of 5×10^4 thermal neutrons/cm^2/sec at a distance of 190 cm from the front face of a graphite block bombarded with 8 MeV deuterons. One thousand tracks lying parallel to the emulsion surface within the depth of focus of the microscope were measured. The mean range (including the C^{14} recoil track) was $5{\cdot}55 \pm 0{\cdot}01\ \mu$. Correction for the C^{14} gives a proton range of $6{\cdot}36 \pm 0{\cdot}05\ \mu$ (energy $0{\cdot}584 \pm 0{\cdot}003$ MeV), Abstr. 7465 (1950). See also Abstr. 8249 (1950), 2934 (1948).

DISCHARGE TUBES . COUNTERS 537.54

537.542

7028. The background counting rate in a Geiger–Müller counter. D. H. PEIRSON. Letter in *Proc. Phys. Soc., Lond. B*, **64**, 427–8 (*May*, 1951).

Describes measurements made on background counts in the field, and discusses them in relation to the soil analyses. Contamination and atmospheric activity were negligible compared with soil activity.

J. D. CRAGGS

537.542

7029. A localizing Geiger counter. S. G. F. FRANK. *Phil. Mag.*, **42**, 612–15 (*June*, 1951).

The constant speed with which the discharge spreads along the wire in a G.-M. counter is used to localize ionizing particles. Signals are obtained from the wire and also from 2 electrodes near its ends; from these signals a pulse is derived whose amplitude indicates the position of the initial ionizing event. Provision is made for stabilizing the speed of spread. A.

537.542

7030. A small BF_3 ionization chamber for absolute neutron measurements. K.-E. LARSSON AND C. TAYLOR. *Ark. Fys.*, **3**, *Paper* 9, 131–46 (1951).

Calculation shows that a small BF_3 chamber can be made which will have characteristics suitable for absolute neutron measurements, even when it is used with electron collection. A chamber has been constructed, and its bias curve is found to agree closely with that calculated. It is shown that the central electrode of such a chamber should be small in diameter, compared with its outer electrode. An amplifier and sonde mounting for use with the chamber are described. A.

537.542

7031. Ionisation chambers for electron dosimetry. J. W. BOAG, F. D. PILLING AND T. WILSON. *Brit. J. Radiol.*, **24**, 341–4 (*June*, 1951).

The construction is described of three types of chambers which measure continuous radiation of about 10^5 r/sec. The whole of the beam passes through the three electrodes of the chamber (all of 0·001 in Al foil). Design data are given by a curve correlating fraction of ionization collected with a parameter, which includes electrode spacing, ionization intensity and voltage applied to the chamber.

L. E. MUSSELL

537.542

7032. Behavior of space charge in diamond crystal counters under illumination. I. A. G. CHYNOWETH. *Phys. Rev.*, **83**, 254–63 (*July* 15, 1951).

The development of a technique is described whereby alternate electric field pulses and white light flashes are used to overcome the difficulty of the formation of space charge in a diamond crystal counter when subjected to bombardment by β-particles. Using the method, a study is made of the behaviour of the space charge field when the electric field strength and flash intensity are varied. The manner in which the space charge grows and decays with time depending on the conditions of the experiment is described. It is shown how, under suitable conditions, steady counting-rates can be obtained; and in particular, how the behaviour of the counter under space-charge-free conditions can be investigated. Qualitative results are also given concerning the effect of illumination of the counter with red and infrared light instead of white light. Preliminary experiments on the effect of temperature on the counter suggest the possibility of permanently preventing the formation of space charge by keeping the temperature of the counter sufficiently high. It is also indicated how experiments at different temperatures could yield information concerning the distribution

of trap depths in the crystal and the mean lifetimes of trapped electrons and holes. A new approach to the problems of solid state physics has thus been developed. The great advantage that it possesses over luminescence methods is that it does not require the emission of light in order to study the electron transitions between trapping states and the ground state and consequently, radiationless transitions can be investigated. A.

537.542

7033. Behavior of space charge free diamond crystal counters under beta-ray bombardment. II. A. G. CHYNOWETH. *Phys. Rev.*, **83**, 264–8 (*July* 15, 1951).

By using the technique described in the preceding Abstr. a study is made of the behaviour of a diamond crystal counter under space-charge-free conditions when subjected to bombardment by beta-rays. The pulse heights caused by the beta-particles are found to be proportional to the energy of the beta-particles over the range 0·66 to 1·0 MeV when a low field strength is used. The trap density in the crystal is found to be of the order of 2×10^{16} per cm^3 and the mean energy required to form an electron hole pair is approximately 7 eV. A.

537.542

7034. The scintillation counter. W. HANLE. *Naturwissenschaften*, **38** (*No.* 8) 176–85 (1951) *In German.*

An up-to-date review of the development of the scintillation counter is given with sections on techniques, phosphors, scintillating liquids and applications. A list of 156 references is included.

G. F. J. GARLICK

537.542

7035. Radioactivity measurements using non-crystalline fluorescent solids. L. PICHAT AND Y. KOECHLIN. *J. Chim. Phys.*, **48**, 225–8 (*May–June*, 1951) *In French.*

A 2% solid solution of 1–1–4–4 tetraphenyl 1–3 butadiene in polystyrene, included before polymerization, is more convenient and more efficient than solid solutions of *p*-terphenyl, anthracene or stilbene as a scintillation system. It is better than tetraphenyl-butadiene in xylene and is equivalent to *p*-terphenyl in xylene. In the region investigated from 0·1% solid solution up to the pure crystal the mean scintillation intensity increases linearly with the logarithm of the concentration of tetraphenyl-butadiene. G. F. J. GARLICK

537.542 : 535.376

Phosphorescent effects with high energy radiation. *See Abstr.* 6892

537.542 : 535.376

Response of some scintillation crystals to heavy particles and electrons. *See Abstr.* 6893–4

537.542 : 539.185.08

7036. Scintillating liquids as neutron detectors. C. E. FALK, H. L. POSS AND L. C. L. YUAN. Letter in *Phys. Rev.*, **83**, 176 (*July* 1, 1951).

Integral bias curves are obtained for the scintillations produced in 0·5% solutions of terphenyl in xylene by 14 MeV neutrons and by the ThC″ and Co^{60} rays. The efficiency for a cell 1 in long × 1¾ in dia. is 5–10%. The effect of cell dimensions and optics are investigated. The cells show a disproportionately high sensitivity to γ-rays. G. F. J. GARLICK

537.542 : 616–

7037. Scintillation-counter brain needle. D. KOHL *Nucleonics*, **8**, 79–83 (*March*, 1951).

A small phosphor ($\sim$ 6 mm^3) is situated at the end of a 3 mm dia., 8 cm long Duralumin tube and light is piped from it along the tube to a photomultiplier with the help of a lucite rod. The instrument has a number of advantages over the G.M. type needle probe, including greater stability against physical strain and shock and a more localized field of detection. L. R. SHEPHERD

537.542 : 621.318.572 : 621.38

7038. Scintillation counting with an EMI 5311 photomultiplier tube. J. S. ALLEN AND T. C. ENGELDER *Rev. Sci. Instrum.*, **22**, 401–2 (*June*, 1951).

The EMI 5311 photomultiplier tube differs from the usual tube in that the electrodes are of the Venetian blind type rather than electron optical lenses. This type of tube has been used as a scintillation counter with *trans*-stilbene crystals. The shape of the scintillation pulse is characterized by a rise time of $7\cdot2\times10^{-9}$ sec and a decay time of $1\cdot8\times10^{-8}$ sec. It is concluded that this type of multiplication structure results in an unusually large spread in the transit time of electrons moving through the structure. A.

537.542 : 621.318.572

7039. A new type of high speed coincidence circuit. Z. BAY. *Rev. Sci. Instrum.*, **22**, 397–400 (*June*, 1951).

A new coincidence device using crystal diodes has been developed. The circuit does not necessitate equalizing and can be used for pulses with an amplitude spread of two orders of magnitude. The principle is to compare two measurements: one made in one of the channels, and the other made between the two channels. Resolving times down to 3×10^{-10} sec have been obtained, which represent an improvement of one order of magnitude over former circuits. The improvement in the sensitivity also turned out to be about one order of magnitude. The circuit should be useful in nuclear experiments in determining decay times, disintegration rates, and for the reduction of noise in scintillation counters. A.

537.542 : 621.395.645.024

7040. An improved d.c. amplifier for portable ionization chamber instruments. N. F. MOODY. *Rev. Sci. Instrum.*, **22**, 236–9 (*April*, 1951).

In d.c. amplifiers for ionization chambers the zero stability is commonly increased by applying negative feedback. However, in portable instruments with l.v. battery supplies it is difficult to achieve the loop gain required and, further, it is desirable to reduce the instrument time-constant, which is inversely $\propto$ the loop gain. In the radiation monitor described the loop gain is increased by using a pentode cathode follower in the feedback loop and by applying positive feedback by returning the anode load of the electrometer to the screen supply of the cathode follower. This supply is tied to the cathode and thus follows the cathode potential. The time-constant is reduced by a factor of 5. On the most sensitive range the instrument handles a full-scale current of 4×10^{-13} A. W. G. STRIPP (R)

537.542

7041. Clouds produced in an expansion chamber by ultra-violet light. F. J. M. FARLEY. *Proc. Roy. Soc. A*, **207**, 527–39 (*July* 23, 1951).

Clouds are produced in an expansion chamber filled with air and water vapour by irradiating with u.v. light through a quartz window, and expanding shortly afterwards. It is shown that the condensation does not occur upon charged particles, but on certain electrically neutral nuclei, not yet identified. By varying the wavelength of the u.v. light it is shown that the condensation is initiated by atomic O, liberated by the action of the radiation on O molecules. Similar effects are produced when an intense beam of deuterons is passed into the chamber. A.

537.543 : 621.3.015.1 : 621.385.2

7042. Potential and gradient distributions in parallel plane diodes at currents below space-charge-limited values. W. M. BRUBAKER. *Phys. Rev.*, **83**, 268–70 (*July* 15, 1951).

The equations for electron motion in a plane diode under the influence of space charge are integrated. The solution is expressed in terms of four dimensionless numbers, normalized so that their range is from zero to unity. The gradient at the cathode is expressed as a function of the current density as it varies from zero to space-charge-limited values. Space distributions of potential and gradient are given in terms of the location of the plane of interest between the cathode and the anode for a number of specific current densities. Evidence is shown of the existence of a plane for which the gradient is essentially independent of the current density. A.

IONIZATION . THERMIONICS 537.56/.58

537.56

7043. The lateral distribution of ions across the track of an ionizing particle. II. J. READ. *Brit. J. Radiol.*, **24**, 345–7 (*June*, 1951).

Further consideration of the equilibrium distribution given in Pt I [Abstr. 6287 (1949)]. In liquids, it is not possible at present to state that there is a difference in the initial lateral distribution of negative ions produced by γ- or X-rays compared with that due to α-rays. If the difference does exist it probably results in related differences in radiation-chemical and radiobiological results. Furthermore, the dielectric constant of the solvent and its temperature, by their influence on the critical linear ion density KkT/e^2, may exert a previously unsuspected difference. T. A. CHALMERS

537.565

7044. On the motion of gaseous ions in a strong electric field. I. G. H. WANNIER. *Phys. Rev.*, **83**, 281–9 (*July* 15, 1951).

This paper applies the Boltzmann method of gaseous kinetics to the problem of positive ions moving through a gas under the influence of a static, uniform electric field. The ion density is assumed to be vanishingly low, but the field is taken to be strong; that is, the energy which it imparts to the ions is not assumed negligible in comparison with thermal energy. Attention is focused upon the computation of velocity averages, and the drift velocity in particular, rather than a complete knowledge of the entire velocity distribution. It is shown that the problem so formulated is completely soluble if the mean free time between collisions of ions and molecules is a constant; this is the case for the so-called polarization force between ions and molecules which predominates over other forces at low temperature. A method for obtaining averages to any desired accuracy in the general case is developed and applied to the hard sphere model for the high field range and mass ratio 1. An application of the resulting formula to experimental material has been published earlier. A.

537.583

7045. The mechanism of thermionic emission of an oxide cathode in impulse conditions. YA. E. POKROVSKIĬ. *J. Exp. Theor. Phys., USSR*, **21**, 423–8 (*March*, 1951) *In Russian.*

Author assumes the following mechanism: Before the extraneous field is applied, there is dynamic equilibrium between the electrons of the cloud of the space charge, those of the conductivity zone and the electrons of the localization levels, respectively. If the external field is strong enough, all the electrons arriving from the zone of conductivity in the vacuum are carried by the field to the anode. The equilibrium will be upset because the electrons from the oxide penetrate into the vacuum without returning (the cloud of the space charge being dissipated by the external field), the concentration in the conductivity zone thus falling and only partly being replenished by electrons acceding from the core. The reduction of the concentration goes on until the influx from the core establishes a new equilibrium, the latter then determining the emission set up. This may be theoretically based on semiconductor conceptions. The confirmation of this theory is obtained by a quantitatively correct formula for the fatigue of the oxide cathode. The physical meaning of the constant characterizing this fatigue becomes understandable and its characteristics agree with experimental findings. The influence of the barrier layer may be explained qualitatively in agreement with the experiment. No completeness is claimed for the theory, but that it represents a reliable foundation for further work in this field. B. F. KRAUS

537.583

7046. The origin of bombardment-enhanced thermionic emission. J. B. JOHNSON. *Phys. Rev.*, **83**, 49–53 (*July* 1, 1951).

Measurements on bombardment-enhanced thermionic emission from oxide cathodes show that (*a*) the effect is not related to normal fading and recovery of thermionic emission; (*b*) the emitted electrons have energies in the thermal range rather than in the secondary range. Calculations indicate that the electron bombardment releases more than enough internal secondaries to account for the effect as increased thermionic emission. A more comprehensive theory is needed for explaining why the observed effect is not even larger. A.

COSMIC RAYS 537.591

537.591 : 523.16

Cosmic radiation and cosmic magnetic fields. *See Abstr.* 6679–80

537.591.1

7047. A note on the development of the nucleon component of the cosmic radiation in air when ionization losses are accounted for. H. MESSEL. *Phys. Rev.*, **83**, 26–30 (*July* 1, 1951).

The development of the nucleon component of the cosmic radiation in air is considered in terms of a model previously discussed by Messel and Ritson, with the inclusion of ionization losses. The results obtained are compared with experiment, and good qualitative agreement is found. The good qualitative agreement found strongly suggests that the Heitler–Jánossy assumptions regarding the nucleon-nucleon collision cross-section are valid. But from a quantitative standpoint it appears that a number of points require revision. There is little doubt that the development of the nucleonic component can in fact be well accounted for in terms of a cascade process. Results are presented in graphic form for neutrons, protons, neutrons plus protons and their ratio. A.

537.591.1

7048. The proton component of the cosmic radiation at sea level. E. L. GOLDWASSER AND T. C. MERKLE, JR. *Phys. Rev.*, **83**, 43–6 (*July* 1, 1951).

The range spectra of mesons and protons in the sea-level cosmic radiation have been investigated with a cloud chamber that had within its volume a total of 10 cm, of Pb equivalent absorbing material. Measurements were made with absorbers equivalent to 2, 7, 17 and 48 cm of Pb above the apparatus. The masses of stopping particles were determined by observing the momentum and range of each particle. 161 mesons (mass $= 205 \pm 2m_e$) and 72 protons (mass $= 1\,900 \pm 44m_e$) were observed. No evidence was found for the existence of any particles with intermediate mass. Data obtained under each of the 4 thicknesses of moderating absorber were used to give 4 points on the differential range spectra for mesons and protons. The meson spectrum has a peak occurring in the range between 17 cm and 30 cm of Pb. The observed proton component can be interpreted either as the residual of a flux of protons which is incident on top of the moderator and degraded in energy with passage through the moderator, or as a flux of protons produced in the moderator by an incident neutral radiation, probably neutrons. The proton range spectrum fits an exponential absorption law with a mean free path of 12 cm of Pb. This is just the order of attenuation to be expected from nuclear interactions of protons or neutrons. Thus, if the protons are incident on the moderator, their differential range spectrum would have to have been flat in the region between 8 and 54 cm range in Pb. This implication, together with the behaviour of the proton component in the Pb absorber plates observed in the cloud chamber, points to the incident neutron hypothesis as the more probable explanation of the observed protons. A.

537.591.1

7049. Barometric and temperature coefficients of frequency of small cosmic-ray bursts and of burst-corrected cosmic-ray ionization.

Add to Abstr. 4502 (1951): For the bursts, the averages of the coefficients for 19 individual months are $-1{\cdot}54\%$/mm Hg and $-0{\cdot}98\%/°$C, while the averages for those months with significance ratio above the 2% level are $-2{\cdot}44\%$/mm Hg and $-1{\cdot}66\%/°$C. For the burst-corrected CR ionization the averages of the coefficients for 19 individual months are $-0{\cdot}154\%$/mm Hg and $-0{\cdot}038\%/°$C, while the values computed for 581 days are $-0{\cdot}174\%$/mm Hg and $-0{\cdot}056\%/°$C. Little difference from the latter values are found with computations based on monthly means. [Added at the author's request].

537.591.1

7050. On fluctuations and the general distribution problem in electron cascades. W. T. SCOTT. *Phys. Rev.*, **82**, 893–900 (*June* 15, 1951).

Recent developments of Bhabha, Friedman and Jánossy are applied to the general probability distribution problem of electron cascades (cosmic-ray showers). In particular, it is shown that the master function giving the probability of any number of particles with any given energy distribution at a depth t in a shower is determined, in principle, by the average energy spectrum. Certain theorems connecting the various functions are derived, and a discussion is given of the as yet unsolved problem of getting satisfactory analytic or numerical results from the formalism. Only the simplified model originated by Furry has been discussed, but the theorems embody many properties of the actual electron-photon multiplication process. A.

537.591.1

7051. Investigations on large cosmic-ray bursts. E. F. FAHY. *Phys. Rev.*, **83**, 413–21 (*July* 15, 1951).

Observations on large cosmic-ray bursts have been performed at the altitude of 3 500 metres with a model C meter surrounded by thick Pb shields. G.-M counters, connected to appropriate electronic circuits, were placed over these shields to record extensive air showers simultaneously with bursts. About 2% of the 100 particle bursts and about 14% of the 1 000 particle bursts under $10{\cdot}7$ cm Pb are produced by extensive air showers. This fraction continues to increase with increasing burst size and becomes almost 100% for bursts of >4 000 particles. The experimental observations are consistent with the assumption that the part of the burst-producing radiation which does not consist of air showers or of μ-mesons is attenuated in Pb with the absorption mean-free-path of 346 ± 36 g/cm². μ-mesons (spin 1/2) produce $68 \pm 5\%$ of the bursts in a model C meter under $10{\cdot}7$ cm Pb at sea level. It is pointed out that the high energy N-component of the cosmic radiation (i.e. those particles having strong nuclear interactions with matter) can produce enough electronic radiation to account for the observed burst frequency, if $\int_0^1 z^2 p(z)dz = 0{\cdot}12$, where $p(\varepsilon/E)d(\varepsilon/E)$ is the probability per nuclear collision that an N-ray of high energy E produces electronic radiation of energy $(\varepsilon, d\varepsilon)$. The neutral meson mechanism satisfies this condition, provided one assumes that practically

all of the energy of a high energy N-ray is carried away by mesons when a nuclear collision in Pb takes place, and that one-third of this energy goes into neutral mesons. The calculations are made on the assumption that the absorption mean-free-path of high energy N-rays is 124 g/cm² in air, and that the directional intensity of the primary cosmic radiation with energies $> E$ BeV is $0{\cdot}12(4{\cdot}5/E)^2$ sterad^{-1} cm^{-2} sec^{-1} at the top of the atmosphere. A.

537.591.15

7052. Experiments on large cosmic-ray bursts under thick absorbers at 11,500 feet elevation. T. G. Stinchcomb. *Phys. Rev.*, **83**, 422–31 (*July* 15, 1951).

Using a Carnegie Model "C" ionization chamber together with Geiger–Mueller tube coincidence circuits, the nature of the radiation which produces large bursts (> 200 particles) of cosmic rays under thick absorbers at 11 500 ft elevation has been investigated at Climax, Colorado. The percentage of this radiation which was accompanied by air showers was determined and found to be dependent upon the burst size. The absorption mean free paths for the burst-producing radiation (excluding bursts produced by μ-mesons and by air showers) were measured in Pb and Fe and found to be 350 ± 40 g/cm² in Pb and 240 ± 20 g/cm² in Fe. The barometric effect on this radiation yielded an absorption mean free path of 65 ± 14 g/cm² in the atmosphere, and the zenith angle distribution was found to be that due to an absorption mean free path of 75 ± 14 g/cm². These results are shown to indicate that the radiation responsible for these large bursts consists largely of protons and π-mesons of energy > 60 BeV. A.

537.591.3

7053. Cloud chamber analysis of stopped particles in the sea-level cosmic radiation. G. M. Nonnemaker and J. C. Street. Letter in *Phys. Rev.*, **82**, 564 (*May* 15, 1951).

A cloud chamber in field 4 300 gauss was used to study the momentum spectrum of particles traversing 140 g cm^{-2} Pb above chamber and stopped in further 88 g cm^{-2} below it. The momentum cut-off is clearly that of μ-mesons, and the charge ratio $(+/-)$ is $0{\cdot}94 \pm 0{\cdot}07$. J. G. WILSON

537.591.3

7054. Absorption of cosmic rays in lead. G. R. Heyland and W. E. Duncanson. Letter in *Nature, Lond.*, **167**, 895–6 (*June* 2, 1951).

An arrangement consisting essentially of 5 overlapping counter telescopes of high counting rate was used to measure the absorption curve up to 30 cm Pb. The absorption curve was independent of the position of the absorber (above or within the telescope), and intensity decreased continuously with increasing thickness of absorber over the whole range.

J. G. WILSON

537.591.5 : 551.594.5

7055. Correlation of auroras with increased cosmic ray intensities. (November 19, 1949). N. C. Gerson. Letter in *Nature, Lond.*, **167**, 894–5 (*June* 2, 1951).

Aurorae visible in eastern N. America between 2 355 G.M.T., Nov. 19th, 1949, and 0145 G.M.T., Nov. 20th, are correlated with the increase of cosmic ray intensity observed at many stations between about 1000 and 1300 G.M.T., Nov. 19th, with the solar flare of 1029 G.M.T., Nov. 19th, and with ionospheric disturbances between 1030 and 1100 G.M.T., Nov. 19th. The time lag of the aurorae suggests a transit velocity $\sim 3 \times 10^8$ cm/sec^{-1} from the sun corresponding to electrons of about 20 eV or protons of 40 keV. The difficulty of connecting the aurorae with electrons is indicated. J. G. WILSON

537.591.8

7056. A note on the V-particle. C. B. A. McCusker and D. D. Millar. Letter in *Nuovo Cim.*, **8**, 289–91 (*April*, 1951).

Two cloud chamber pictures are reported showing V-shaped tracks obtained at sea level. On one of the pictures there are 3 V's, two of which have their vertices in the gas of the chamber. E. P. GEORGE

537.591.8

7057. Observation of cosmic ray events in nuclear emulsions exposed in a glacier at 3 550 m. J. B. Harding. *Phil. Mag.*, **42**, 651–62 (*June*, 1951).

Photographic emulsions have been exposed at various depths under ice at 3 550 m. The variation in the numbers of slow μ-mesons with depth is in fair agreement with a predicted variation. From the variation of the numbers of "stars" with depth, the best estimate for the absorption mean free path of the star-producing radiation is 170 ± 10 g/cm². The variation of the numbers of π^+-mesons with depth is consistent with an absorption path length for nuclear interaction corresponding to a few times the geometric value. A large upward stream of π-mesons has been observed and possible interpretations are discussed. A.

537.591.8 : 539.172

7058. The nuclear interactions of cosmic rays. G. D. Rochester and W. G. V. Rosser. *Rep. Phys. Soc. Progr. Phys.*, **14**, 227–87 (1951).

The report deals with the types of nuclear interaction, the properties of nuclear-interacting particles, and the correlation of nuclear events in the atmosphere and in condensed matter. The empirical data for evaporation stars are collected and it is shown that the statistical theory of the nucleus can account for much of the data. The methods of investigating meson showers are outlined and the principal results are given. Recent work on the new heavy unstable particles is included in this section. An account is given of the nuclear interaction of non-nucleonic particles, i.e. electrons, photons, μ-mesons and π-mesons. Experiments giving information about the interactions of nucleons in the atmosphere and in condensed matter are discussed. The nucleonic components in the atmosphere and their correlation are discussed in detail. Some of the main problems awaiting solution are mentioned. A.

MAGNETISM 538

538.082.1

7059. Proposed dynamic method for magnetic measurements in small fields. Y. L. Yousef, H. Mikhail and R. K. Girgis. Note in *Rev. Sci. Instrum.*, **22**, 342–3 (*May*, 1951).

The method proposed depends on the periodic pull

experienced by a small suspended coil carrying alternating current when the test material is held with one end at the centre of the coil. The suspended system is adjusted to be resonant at the supply frequency and its amplitude of displacement is measured, this being proportional to the susceptibility of the test material. A. E. DE BARR

538.082.101

7060. The measurement of magnetic susceptibility by the Faraday method. C. COURTY. *C.R. Acad. Sci., Paris*, **232**, 2012–14 (*May* 28, 1951) *In French.*

A brief discussion of practical difficulties.

E. P. WOHLFARTH

538.083.9

7061. Magnetic field measurements with peaking strips. J. M. KELLY. *Rev. Sci. Instrum.*, **22**, 256–8 (*April*, 1951).

Describes the use of a strip of a material with a rectangular *B–H* loop for the measurement of static and dynamic magnetic fields to an accuracy of approximately 0·02 oersteds. Operation of the device depends upon the large flux changes which occur as the field in which the strip is placed changes through the values corresponding to the coercive force. Thus voltage pulses are produced, in a search coil around the wire, at definite field strengths. With the aid of suitable bias coils fields from zero to several thousand oersteds may be measured.

A. E. DE BARR

538.1

7062. A metallic monocrystal in a magnetic field. V. A. DMITRIEV. *J. Exp. Theor. Phys., USSR*, **20**, 1019–21 (*Nov.*, 1950) *In Russian.*

Averaging of the kinetic equation of the conductivity electrons, considering the magnetic field, enables the kinetic coefficients determining the galvanomagnetic phenomena to be calculated. The approximation process is simplified by the fact that the main characteristic required is the current density and that therefore terms of the approximating series not contributing to current density may be neglected, and further by certain symmetry and anti-symmetry properties of the tensor components of the magnetic field making other terms cancel out. Similar relations also obtain for the surface of constant energy reducing to zero the integral of the odd function of the wave vector. The number of vanishing terms is propagated through successive approximations, i.e. it increases correspondingly. The results agree, at least qualitatively, with experimental facts. B. F. KRAUS

538.1

7063. Collective electron ferromagnetism in metals and alloys. E. C. STONER. *J. Phys. Radium*, **12**, 372–88 (*March*, 1951).

A comprehensive review of the author's theoretical treatment (1938, 1939) and of more recent extensions and comparisons with experimental results for a wide range of ferromagnetic metals and alloys. A brief discussion is also given of recent work on the fundamental quantum-mechanical problems of ferromagnetism; work in progress on the theory of the magneto-caloric effect and of electrical conduction is referred to. E. P. WOHLFARTH

538.

7064. Influence of order on magnetic properties. R. SMOLUCHOWSKI, *J. Phys. Radium*, **12**, 389–9 (*March*, 1951).

New theoretical ideas relating to the ferromagneti properties of binary alloys are outlined. Her fluctuations of electron concentration in equivale groups of atoms (a central atom and nearest an next-nearest neighbours) are considered. The in fluence of order on properties such as saturatio moment, magnetostriction, Curie temperature, mag netic anisotropy, coercivity and permeability discussed. The influence of the exchange contr bution to the total energy on ordering is als considered. E. P. WOHLFART

538.

7065. New concept of the electronic state in ferro magnetics. Introduction of the idea of intermitter activation. R. FORRER. *J. Phys. Radium*, **12**, 402–1 (*March*, 1951) *In French.*

A review of the author's treatment, previousl published, and application to a wide range of non ferromagnetic and ferromagnetic metals and alloys.

E. P. WOHLFART

538.

7066. The coercive field. L. WEIL. *J. Phys Radium*, **12**, 437–47 (*March*, 1951) *In French.*

A review of the theory of coercivity, both for soli ferromagnetics and for small single-domain particles Recent experimental results are discussed in suppor of theory. E. P. WOHLFART

538.1 : 538.2

7067. Magnetization by rotation (initial suscepti bility, coercive field). C. GUILLAUD. *J. Phys Radium*, **12**, 492–7 (*March*, 1951) *In French.*

A theoretical discussion and application to th hysteretic properties of MnBi, Mn_2Sb, a singl crystal of Co and a highly coercive Co ferrite. Th experimental results are well covered by invoking th action of magneto-crystalline and magneto-elasti anisotropy forces. E. P. WOHLFART

538.1 : 538.2

7068. Limitation of the range [of applicability] o the Rayleigh law in alternating fields discussed in th light of recent theoretical and experimental investi gations. I. EPELBOIN. *J. Phys. Radium*, **12**, 361–7 (*March*, 1951) *In French.*

A brief discussion of the Rayleigh law is followe by an account of more recently proposed relations Recent relevant magnetic measurements by th author and others are described. The causes of departure from the Rayleigh law are studied b means of structural investigations (electrolyti polishing techniques). E. P. WOHLFART

538.1 : 539.1

7069. On ferromagnetism, paramagnetism an cohesive energy of transition metals and their alloys T. G. OWE BERG. *J. Phys. Radium*, **12**, 418–2 (*March*, 1951).

A general coordination of the saturation moment of binary ferromagnetic alloys and compounds, a dependent on electron concentration, is suggested The correlation breaks down for some Fe alloys which are discussed separately. The cohesive energ

is expressed in a simple empirical formula and the temperature variation of the heat of sublimation is discussed. Application is made to the paramagnetism of Ni. E. P. WOHLFARTH

538.113

7070. Dipolar domains in paramagnetic crystals at low temperatures. C. KITTEL. Letter in *Phys. Rev.*, **82,** 965–6 (*June* 15, 1951).

Draws the analogy with ferromagnetic domains and derives formulae giving the order of magnitude of several physical quantities characterizing dipolar domains, such as domain wall energy and thickness. E. P. WOHLFARTH

538.113 : 537.312.62

7071. The diamagnetism of free electrons in finite systems. R. B. DINGLE. Letter in *Phys. Rev.*, **82,** 966 (*June* 15, 1951).

Criticizes a paper by Osborne [Abstr. 3532 (1951)]. It is shown that perfect diamagnetism ($\kappa = -1/4\pi$) should only occur in specimens of extremely large radius, R, since κ at very low fields is only $(R/d)^{\frac{1}{3}}$ times as large as the Landau value ($\sim -10^{-6}$), where d is the mean interelectronic separation. E. P. WOHLFARTH

538.114 : 539.22 : 530.162

The antiferromagnetic and order-disorder transitions. *See Abstr.* 6760

538.221 : 539.153

Calculation of the Weiss factors in Fe, Co and Ni. *See Abstr.* 7195

538.221/.222 : 539.185 : 535.42

7072. Neutron diffraction by paramagnetic and antiferromagnetic substances. C. G. SHULL, W. A. STRAUSER AND E. O. WOLLAN. *Phys. Rev.*, **83,** 333–45 (*July* 15, 1951).

Neutron scattering and diffraction studies on a series of paramagnetic and antiferromagnetic substances are reported. The paramagnetic diffuse scattering predicted by Halpern and Johnson has been studied, resulting in the determination of the magnetic form factor for Mn^{++} ions. From the form factor, the radial distribution of the electrons in the 3*d*-shell of Mn^{++} has been determined, and this is compared with a theoretical distribution of Dancoff. Antiferromagnetic substances are shown to produce strong, coherent scattering effects in the diffraction pattern. The antiferromagnetic reflections have been used to determine the magnetic structure of the material below the antiferromagnetic Curie temperature. For some substances the magnetic unit cell is found to be larger than the chemical unit cell. The temperature dependence of the antiferromagnetic intensities has been studied, and the directional effects which characterize neutron scattering by aligned atomic moments have been used to determine the moment alignment with respect to crystallographic axes. From studies with magnetic ions possessing both orbital and spin moments, it is found that the antiferromagnetic intensities contain partial orbital moment components along with the spin moment component. The degree of orbital moment contribution agrees satisfactorily with that predicted by models of lattice quenching. A.

538.221

7073. Gyromagnetic ratios in ferromagnetics of the iron group. A. J. P. MEYER. *J. Phys. Radium*, **12,** 303–4 (*March*, 1951) *In French.*

A brief review of work already published [Abstr. 4524 (1951)]. The g-values of Fe, Ni and some interferromagnetic, iso-electronic alloys were found to be very close to 2·0. E. P. WOHLFARTH

538.221

7074. Relation between structure and magnetic properties of iron-nickel alloys close to $FeNi_3$. E. JOSSO. *J. Phys. Radium*, **12,** 399–401 (*March*, 1951) *In French.*

Dilatometric measurements on the changes of the specific volume accompanying the order-disorder transformation in $FeNi_3$ are used to determine the equilibrium diagram of that transformation. The establishment of order is accompanied by an increase of the Curie temperature and of the magnetostriction coefficient. The effects of adding a small amount of molybdenum to the alloy are discussed. E. P. WOHLFARTH

538.221

7075. Saturation moments and Curie temperatures of isoelectronic face-centred cubic alloys of the iron group. P. TAGLANG. *J. Phys. Radium*, **12,** 414–17 (*March*, 1951) *In French.*

Experiments on Fe–Co–Ni alloys lead to a linear variation of the Curie temperature, θ, as a function of the saturation moment, μ, for alloys having the same electronic concentration $\bar{Z}$. The value of μ extrapolated to $\theta = 0$ is a linear function of $\bar{Z}$ with $d\mu_{\theta=0}/d\bar{Z} = -1\ \mu_B$ and vanishing at $\bar{Z} = 28{\cdot}56$. E. P. WOHLFARTH

538.221

7076. Recent progress in the field of permanent magnets. K. HOSELITZ. *J. Phys. Radium*, **12,** 448–58 (*March*, 1951).

An extensive review dealing with the older magnet steels, precipitation-hardening alloys (e.g. Cunife, Vicalloy), magnets made from powders, and, mainly, with diffusion hardening alloys containing Fe, Ni, Al and frequently Co, Cu and Ti (Alnico, Alcomax). The causes of high coercivity and of the anisotropic properties of alloys cooled in a magnetic field are discussed. E. P. WOHLFARTH

538.221

7077. Magnetic properties of αFe_2O_3. C. GUILLAUD. *J. Phys. Radium*, **12,** 489–91 (*March*, 1951) *In French.*

Preliminary results for a very pure specimen are given; measurements of the magnetization as a function of temperature and field indicate an anomalous variation of susceptibility at about −50°C, below which temperature the substance is paramagnetic with a temperature-independent susceptibility. The susceptibility above the ferromagnetic Curie point (680°C) obeys a Curie–Weiss law fairly closely. E. P. WOHLFARTH

538.221

7078. Determination of the width of elementary domains in a single crystal of iron-silicon. L. F. BATES. *J. Phys. Radium*, **12,** 504–6 (*March*, 1951) *In French.*

The results of powder-pattern experiments are

compared with Néel's theoretical predictions of the variation of line spacings with field. E. P. WOHLFARTH

538.221

7079. Ferromagnetic resonance. J. H. VAN VLECK. *Physica*, **17**, 234–52 (*March–April*, 1951).

Ferromagnetic resonance absorption differs from paramagnetic in that the demagnetizing fields arising from dipolar interaction make the resonant frequency differ from $Heg/4\pi mc$. Kittel's fundamental formula embodying these demagnetizing effects may be derived either macroscopically or microscopically. The macroscopic approach is simpler, especially when the corrections caused by the energy of anisotropy are included, but gives less insight concerning the physical conditions under which the formula is valid. The origin of the width of the ferromagnetic resonance lines is a subject imperfectly understood at present, as none of the mechanisms of line-broadening so far proposed (dipolar interaction, spin-lattice coupling, damping by eddy currents) is satisfactory. The "spectroscopic splitting factor" g involved in Kittel's formula for the resonance frequency is not the same as the anomaly g' in the gyromagnetic ratio. The relation $g - 2 = 2 - g'$ predicted by theory does not hold well experimentally. The cause of the discrepancy is at present not clear, but it is stressed that anisotropic exchange forces of pseudo-dipolar structure may have an important influence both on the breadth and proper frequency of the resonance lines, especially in non-cubic crystals. In conclusion, a brief discussion is given of existing experimental data on resonance in antiferromagnetic media. A.

538.221

7080. Ferro-magnetic resonance in thin Ni-films. J. H. E. GRIFFITHS. *Physica*, **17**, 253–8 (*March–April*, 1951).

The films were prepared by evaporation on to mica and were from 0·1 μ to 3 μ thick. It was found that the value of magnetic field for which the absorption was a maximum appeared to be dependent on the thickness of the film. The results are interpreted in terms of Kittel's equation which involves the quantity $(N_y\text{-}N_z)\ I$ where N_y and N_z are the demagnetizing factors normal to the plane of the film and in the direction of the static magnetic field respectively and I is the saturation intensity of magnetization. A new oscillation type of magnetometer is described by which both I and $(N_y\text{-}N_z)$ may be measured. Results of these measurements combined with the ferromagnetic resonance measurements on the same samples of thin films, show that the g value for Ni is independent of thickness and that the change in resonance magnetic field is, in nearly all cases, due to a change in $(N_y\text{-}N_z)$. This is interpreted as arising from strain in the Ni film, due to differential contraction of the Ni and the mica substrate on cooling from the annealing temperature. Calculations show that this should give a change of the right order of magnitude and other experiments are described which support this view. A.

538.221 : 538.23

7081. Ferromagnetism in weak fields and the Curie point. R. GOLDSCHMIDT. *J. Phys. Radium*, **12**, 355–60 (*March*, 1951) *In French.*

A review of the magnetic properties of Fe–Si and Fe–Ni alloys, used in technology, in low alternating magnetic fields. The various mechanisms contributing to the total energy loss (hysteresis, eddy current, magnetic viscosity) are discussed. The temperature variation of initial permeability and energy losses near the Curie point, materials with apparently two Curie points and those with anisotropic properties are considered. Some original experimental results on energy losses are given and the author's earlier theoretical treatment of losses is recalled.

E. P. WOHLFARTH

538.221 : 538.24

7082. g-Factors of binary ferrites at low temperatures. T. OKAMURA AND Y. TORIZUKA. Letter in *Nature Lond.*, **167**, 986 (*June* 16, 1951).

Reports results of measurements on Ni–Zn, Ni–Mn and other ferrites between −195°c and 0°c. The variation of g with composition is compared with the variation of the saturation magnetization with composition [Abstr. 6640 (1950)]. E. P. WOHLFARTH

538.221 : 539.4.015

7083. Relations between initial and final orientations in rolling and annealing of silicon ferrite. B. F. DECKER AND D. HARKER. *J. Appl. Phys.*, **22**, 900–4 (*July*, 1951).

An investigation of the effects of rolling and annealing on the orientation of individual grains in Si ferrite strip yielded results which led to the formulation of a theory for the appearance of the "magnetic" orientation in the final processed strip. It is proposed that, in a fine-grained strip of Si ferrite, those grains which are already in the "magnetic" orientation before rolling will keep that mean orientation during rolling but become more highly strained than other grains, and therefore, they will become the portions of the cold-rolled strip with highest free energy. In the annealing process these highest energy regions will recrystallize first, becoming lowest energy regions which will be able to consume the now higher energy regions surrounding them. Since these nuclei have the "magnetic" orientation, the final product also attains the "magnetic" orientation. A.

538.221 : 539.4.016

7084. Iron-silicon alloys heat treated in a magnetic field. M. GOERTZ. *J. Appl. Phys.*, **22**, 964–5 (*July*, 1951).

Heat treatment in a magnetic field has been found effective for Fe–Si alloys between 2% and 10% Si, the highest maximum permeability being obtained at about 6·5% Si. In a single crystal of this composition magnetized parallel to a [100] direction, the hysteresis loop is squared by the magnetic anneal and the maximum permeability is increased from 50 000 to 3 800 000, the highest value yet reported. A.

538.222

7085. A study of the paramagnetism of atomic nuclei by the method of magnetic-spin resonance. S. D. GVOZDOVER AND A. A. MAGAZANIK. *J. Exp. Theor. Phys., USSR*, **20**, 705–21 (*Aug.*, 1950) *In Russian.*

A general solution of the problem of nuclear induction signals is given in the form of integral equations of the Voltaire type. Tedious numerical work is reduced by the use of the appropriate approxi-

nations for linear and sinusoidal longitudinal nagnetic field modulation at various frequencies. The signals obtained with both high and low intensity ransverse radiofrequency inputs are fully discussed nd the methods of measuring relaxation times xplained. Experimental pictures are given and the ongitudinal and transverse relaxation times for rotons in paraffin are given as $T_1 = 3\times10^{-2}$ and $0^{-5} < T_2 < 10^{-4}$ sec respectively at a field of 886 oersteds. D. H. WHIFFEN

538.222

086. Relation between paramagnetic absorption and ermeability. S. A. ALTSHULER. *J. Exp. Theor. Phys., SSR*, **20**, 1047–50 (*Nov.*, 1950) *In Russian.*

General integral relations between the high-requency permeability χ' and absorption coefficient χ'' are established for the case in which the curves of aramagnetic dispersion and absorption express a elation between χ' and χ'' and the magnitude of the atic field H applied. A knowledge of $\chi'(H)$ enables $\chi''(H)$ to be found, and vice versa. They may also e used for calibrating experimental dispersion and osorption curves. The relations are corroborated on mpirical curves obtained by various authors for me frequencies. B. F. KRAUS

538.222

087. A method for measuring paramagnetic osorption and dispersion. R. LACROIX AND R. XTERMANN. *Physica*, **17**, 427–31 (*March–April*, 951) *In French.*

The magnetic susceptibility, χ', of $MnSO_4 . 4H_2O$ as measured as a function of a static magnetic field 9 375 Mc/s by a sensitive coupled cavity method nd χ'' was measured by observing the Q of a cavity. he shape of the resonance curve differs slightly from at of Cummerow *et al.* [Abstr. 1006 (1948)] which ay be due to the elimination of errors arising from tatory polarization [Abstr. 7138 (1951)].

D. H. WHIFFEN

538.222

088. Spin-lattice relaxation in diluted paramagnetic lts. R. J. BENZIE. Letter in *Proc. Phys. Soc., nd. A*, **64**, 507–8 (*May*, 1951).

Variation of spin relaxation time of a paramagnetic lt when diluted with a non-magnetic material is scussed and measurements are recorded for mixed ystals of manganese and zinc ammonium sulphate 4·22°K in a field of 508 gauss. W. R. ANGUS

538.222

089. Paramagnetic resonance and hyperfine structre in the iron transition group. A. ABRAGAM. *ysica*, **17**, 209–12 (*March–April*, 1951).

Theoretical calculations on the h.f.s. of paragnetic resonance lines show very strong disagreeent with experiment for the Cu Tutton salts, Cu osilicate, Mn Tutton salts and fluosilicate. All ese calculations are based on the assumption that e wave function of the ion is correctly represented a single configuration. The suggested influence of cited configurations with 3*d* electrons promoted to e 4*s* shell, turns out to have the wrong sign (Cu) to be negligible (Mn). These discrepancies can be nsistently explained in all these salts by assuming omotion of a 3*s* electron to a 4*s* shell. An earlier attempt in which a covalent bonding was assumed between the ion and the surrounding water molecules explained the h.f.s. but led to wrong values for the *g*'s. A.

538.222

7090. Paramagnetic resonance in iron alums. J. UBBINK, J. A. POULIS AND C. J. GORTER. *Physica*, **17**, 213–20 (*March–April*, 1951).

Experiments on paramagnetic resonance absorption have been carried out on single-crystals of iron ammonium alum with different degrees of magnetic dilution. It is found that absorptions with $|\Delta m| > 1$ occur and that these have to be ascribed to the influence of crystalline electric fields. Agreement with theory is found on the behaviour of the absorption as a function of the angle between external and high frequency oscillating field. A sharp absorption peak at $\frac{1}{3}$ of the central peak field strength is found and an interpretation is given. The discrepancy between the assumption of a cubic crystalline field, the known specific heats of the spin system and the paramagnetic resonance results is discussed. A.

538.222

7091. Paramagnetic resonance at large magnetic dilutions. E. E. SCHNEIDER AND T. S. ENGLAND. *Physica*, **17**, 221–33 (*March–April*, 1951).

Hyperfine structure and saturation effects in the paramagnetic resonance of manganese: The use of a microwave bridge technique in conjunction with a superheterodyne method of reception has made it possible to investigate, at 9 500 Mc/s, the resonance spectra of Mn^{++} ions in ZnS phosphors containing Mn as activator in various concentrations down to 10^{-5}, and in aqueous solutions of Mn-salts down to 0·01 N. Observations at liquid air temperature, while showing no significant change in the width of the resonance lines, have yielded information on spin-lattice relaxation.

Paramagnetic resonance of coloured alkali halides: Single peak resonances have been detected in crystals of NaCl, KCl and KBr containing colour centres. The position of the resonance corresponds to a '*g*' very near to the electron spin value. The width and intensity of the resonance have been studied at a number of concentrations of colour centres; in KCl the width is 50 gauss at 3×10^{17} centres/cm^3. The saturation effect has been investigated. A.

538.222

7092. Microwave paramagnetic resonance spectrum. M. FUJIMOTO AND J. ITOH. *Physica*, **17**, 266–8 (*March–April*, 1951).

538.222

7093. Exchange interaction of nickel ions in nickel fluosilicate crystal. E. ISHIGURO, K. KAMBE AND T. USUI. *Physica*, **17**, 310–18 (*March–April*, 1951).

Using the experimental data of the Larmor-line width and of the spin specific heat, the magnitude of the exchange interaction between the Ni ions in Ni fluosilicate crystal is analysed. A.

538.222

7094. Decomposition of the proton magnetic resonance line in paramagnetic crystals. N. J. POULIS. *Physica*, **17**, 392–404 (*March–April*, 1951).

The fine structure of the proton magnetic resonance

line in single-crystals of $CuSO_4.5H_2O$ and $CuCl_2.2H_2O$ has been observed. The position and number of the lines is strongly dependent on temperature and on the direction of the externally applied magnetic field. In $CuSO_4.5H_2O$ always fewer lines than the theoretical number of 20 were observed. For $CuCl_2.2H_2O$ the theoretical number of 8 lines is reached. The temperature dependence is measured for both crystals at different orientations at 4 temperatures in liquid He and at 2 temperatures in liquid H. At the higher temperatures the deviation from the central position is in first approximation inversely proportional to $T - \Theta$, as would be expected from the law of Curie–Weiss. At the lowest temperatures deviations from this law were found. At 1·5°K the position and width of the lines are measured as functions of the angle between the magnetic field and the crystal axis. This dependence is in good agreement with the theoretical expectation. A.

538.222

7095. Preparation and magnetic properties of magnesium-rich gadolinium-magnesium alloys. F. GAUME-MAHN. *C.R. Acad. Sci., Paris*, **232**, 1815–16 (*May* 16, 1951) *In French.*

Alloys with Gd concentrations up to about 65% by weight were found to be paramagnetic, obeying the Curie–Weiss law. The negative Curie temperature remains constant at about 70°K for concentrations up to about 42% and then decreases linearly. The existence of intermetallic compounds $GdMg_9$ and $GdMg_3$ is suspected. E. P. WOHLFARTH

538.222

7096. Paramagnetic resonance in nickel ammonium sulphate. J. H. E. GRIFFITHS AND J. OWEN. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 583–4 (*June*, 1951).

The resonance from the Ni^{++} ions has been investigated at room temperature for wavelengths between 0·85 cm and 1·79 cm, by the method of observing the power transmitted through a loaded cavity resonator. The results are consistent with the assumption that each of the two ions in unit cell is subjected to a crystalline electric field of rhombic symmetry. The splittings between adjacent levels of the ground state spin triplet ($S = 1$) are found to be 1·85 and 0·77 cm^{-1}, and the g value, assumed isotropic, is 2·25. A.

538.222

7097. Microwave resonance absorption in manganese sulfates. H. KUMAGAI, K. ONO, I. HAYASHI, H. ABE, H. SHÔNO, S. TACHIMORI, H. IBAMOTO AND J. SHIMADA. Letter in *Phys. Rev.*, **82**, 954–5 (*June* 15, 1951).

The paramagnetic resonance half widths for $MnSO_4.0,1,4$, and $5H_2O$ are given. D. H. WHIFFEN

538.222

7098. Paramagnetic resonance in alkali metal solutions at low fields. E. C. LEVINTHAL, E. H. ROGERS AND R. A. OGG, JR. Letter in *Phys. Rev.*, **83**, 182 (*July* 1, 1951).

538.222

7099. Magnetic susceptibilities of praseodymium oxides. S. W. RABIDEAU. *J. Chem. Phys.*, **19**, 874–6 (*July*, 1951).

The magnetic susceptibilities of the 3 oxides of Pr, Pr_2O_3, PrO_2 and Pr_6O_{11}, have been measured with the Faraday magnetic balance over a range of temperatures from 80° to 300°K. The sesqui-oxide and the dioxide have been found to have moments of 3·52 and 2·48 Bohr magnetons, respectively, and to obey the Weiss modification of the Curie law, $\chi(T + \Delta) = C$, over the range of temperatures studied with corresponding values of Δ equal to 55·0° and 104°. A curvature was noted in the plot of $1/\chi$ *v.* T for the oxide Pr_6O_{11}. Thus the Weiss–Curie law does not adequately express the relationship between the susceptibility and the temperature for this oxide. A moment of 2·8 Bohr magnetons was calculated for Pr_6O_{11} from the slope of the above plot between 200° and 300°K. A.

538.222

7100. The magnetic susceptibility of uranium tetrachloride. R. STOENNER AND N. ELLIOTT. *J. Chem. Phys.*, **19**, 1950–1 (*July*, 1951).

The magnetic susceptibility of UCl_4 has been measured in the temperature range 76–354°K. The molar susceptibility is given by the equation $\chi_{mole} = 1{\cdot}22/(T + 39°)$. A.

538.222 : 539.152.2

7101. Hyperfine structure in paramagnetic resonance. B. BLEANEY. *Physica*, **17**, 175–90 (*March–April*, 1951).

Transitions are observed at cm wavelengths between the Zeeman components of the ground electronic state of a paramagnetic ion, using an external magnetic field of a few kilogauss. When the nucleus of the ion has a magnetic moment, the latter produces an additional field of a few hundred gauss acting on the electron. The magnitude of this field depends on the orientation of the nucleus, which normally remains fixed during an electronic transition. The latter is therefore split into $2I + 1$ components, giving a simple verification of the nuclear spin I. In the Fe group, the divalent ions with Kramers degeneracy have been investigated using Tutton salts of the type $MK_2(SO_4)_2$, $6H_2O$, and fluosilicates $MSiF6$, $6H_2O$. The results are as follows: Cu, $3d^9$, $^2D_{5/2}$; isotopes 63, 65; $I = 3/2$; Co, $3d^7$, ^4F; isotope, 59; $I = 7/2$; Mn, $3d^5$, ^6S; isotope, 55; $I = 5/2$; V, $3d^3$, ^4F; isotope 51; $I = 7/2$. A.

538.23 : 538.54

7102. Investigation of mixed ferrites of manganese in weak alternating fields. C. GUILLAUD. *J. Phys. Radium*, **12**, 498–503 (*March*, 1951) *In French.*

A résumé of work already published and of some extensions of that work [Abstr. 6650 (1950)].

E. P. WOHLFARTH

538.24

7103. Magnetic saturation intensity and some other related measurements. W. SUCKSMITH. *J. Phys. Radium*, **12**, 430–6 (*March*, 1951).

An account of some experimental investigations carried out by the author and others: (i) magnetization-temperature curve for a single crystal of Co and investigation of the change of crystal structure at about 400°C; (ii) magnetization measurements on Fe–Al, Fe–Cr and Fe–Ni alloys, and investigation of order-disorder changes in Fe_3Al, Fe_3Cr and $FeNi_3$; (iii) magnetic phase analysis, with special application to the Fe–C system. E. P. WOHLFARTH

538.24 : 538.65

7104. Relation of changes in the cementite Curie temperature to textural changes in steel. D. V. WILSON. Letter in *Nature, Lond.*, **167**, 899–900 (*June* 2, 1951).

Variations of the intensity of magnetization with temperature in a series of cold-worked steels do not support an explanation in terms of the production of a new carbide phase. X-ray examination supports the hypothesis that the changes in Curie temperature are due to changes in interatomic distances in the carbide structure, due to textural stresses.

A. E. DE BARR

538.24 : 538.66

7105. The thermal effects associated with magnetization processes. L. F. BATES. *J. Phys. Radium*, **12**, 59–70 (*March*, 1951).

An account of experiments, principally those by the author, on heat changes accompanying magnetization of ferromagnetic metals and alloys in weak and moderate fields, and of the theoretical interpretation of the experimental results [Abstr. 5572 (1949)].

E. P. WOHLFARTH

538.245

7106. Investigation of the ideal magnetization curves of soft polycrystalline ferromagnetics. L. A. CHERNIKOVA. *J. Exp. Theor. Phys.*, **21**, 514–23 (*April*, 1951) *In Russian.*

Soft ferromagnetics, Armco iron, Permalloys and Ni were investigated. Ideal magnetization curves *v.* chemical composition, heat treatment, temperature and tensile stress in the specimens were plotted. Comparison of the experimental ideal curves with the theoretical curves calculated from Kondorskii's formulae for single and multiple-axed ferromagnetics was carried through and empirical formula for the ideal curves given. The measurements were made by a new differential method evolved for the purpose. This permits of measuring the initial part of the magnetization curve of toroidal specimens more accurately than in previous methods. For Permalloys the experimental curves lie between the theoretical curves for single and multiple-axed ferromagnetics. The curve of Armco iron at low fields lies also between the two theoretical curves, for medium fields approaching the multi-axed theoretical curve. Ideal magnetization curves for materials with positive and negative magnetostriction under tensile stress were investigated. On tensile stressing, i.e. when magnetic texture appears, the ideal curves for negatively magnetostrictive materials lie below curves of non-textured materials; those of positively magnetostrictive materials under tensile stress lie above curve for unstressed materials. On stress relief, i.e. when texture disappears, the ideal curves in both cases revert to the original curves of the unstressed materials. B. F. KRAUS

538.245

7107. The spontaneous magnetization of cobalt. H. P. MYERS AND W. SUCKSMITH. *Proc. Roy. Soc. A*, **207**, 427–46 (*July* 23, 1951).

Describes how measurements of pure specimens of single-crystal close-packed hexagonal and polycrystalline face-centred cubic Co have been made over the temperature range — 183 to 1121°C. The spontaneous magnetization of the hexagonal form was accurately measured from — 183 to 431°C, this latter temperature being determined as the upper transformation temperature of the Co. Complete tables of these measurements are given. By extrapolation the value $162{\cdot}5_5$ was determined for the spontaneous magnetization of hexagonal Co at absolute zero. Measurements on the polycrystalline face-centred cubic material were made from 394°C (this temperature being determined as the lower transformation temperature) to the Curie temperature, determined by extrapolation to be 1121°C. The face-centred cubic material possessed greater magnetization than the hexagonal, and in the temperature range 431 to 950°C it was found to be dependent upon heat treatment, the significant factor being the speed with which the specimen was allowed to cool through the lower transformation temperature. The Curie temperature was not affected. To determine the spontaneous magnetization at very high temperatures the extrapolation technique devised by Weiss and Forrer (1926) was used. When reduced values of magnetization and temperature were calculated it was found that the reduced magnetic equation of state is structure dependent. A.

538.245

7108. Magnetization processes in a ferrite. G. T. RADO AND A. TERRIS. Letter in *Phys. Rev.*, **83**, 177 (*July* 1, 1951).

Answers certain criticisms by Went and Wijn [Abstr. 5563 (1951)] on the problem whether magnetization proceeds by rotation or translation.

E. P. WOHLFARTH

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.51

7109. On the stability of magneto-hydrostatic fields. S. LUNDQUIST. *Phys. Rev.*, **83**, 307–11 (*July* 15, 1951).

The stability of static magnetic fields in an electrically conducting liquid is investigated. The result of the study is applied to the stability of twisted cylindric magnetic fields. It is shown that instabilities may be caused by the twisting of a homogeneous field.

A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.56

7110. On the Huyghens principle for an e.m. wave. R. DE POSSEL AND C. POUGET-MICHEL. *C.R. Acad. Sci., Paris*, **232**, 1819–20 (*May* 16, 1951) *In French.*

The principle is expressed by means of a distribution of electric and magnetic dipoles. L. PINCHERLE

538.561 : 535.14

7111. Considerations regarding the emission of photons from sources of radio waves. R. FÜRTH. *Physica*, **17**, 259–65 (*March–April*, 1951).

Experimental evidence on absorption spectra in the

short radiowave and microwave regions prove convincingly that the quantum theory of optical spectra holds in a range of wavelengths in which classical electrodynamics is usually applied unhesitatingly. Thus it has to be assumed that radiation from a short-wave transmitter actually occurs in the form of single photons of energy $h\nu$. But according to the principles of quantum theory the only sources which can produce a monochromatic electromagnetic radiation are electronic systems with sharply defined quantum states. A transmitter of radiowaves on the other hand is characterized by the broad band levels of the conduction electrons of its circuit. As the emission of photons is connected with the transition of individual electrons from higher to lower levels one would expect the radiation to have a continuous spectrum independent of the macroscopic proper frequencies of the oscillating circuit. It is the purpose of the present paper to attempt a clarification of this apparent inconsistency. A.

538.561 : 537.521

7112. Radio wave generation by multistream charge interaction. J. FEINSTEIN AND H. K. SEN. *Phys. Rev.*, **83**, 405–12 (*July* 15, 1951).

The excitation of plasma oscillations in travelling beams is reviewed; analytic and graphical methods are employed to ascertain the ranges of parameters over which wave growth may exist and to determine contours of constant amplification factor. The effect of thermal velocities is taken into account by utilizing approximations to a Maxwellian distribution. It is found that the possibility of growth exists even for beam injection velocities $\ll$ the mean thermal motion in the region; narrow band widths are encountered under these circumstances. Possible applications to solar phenomena are indicated. An investigation of the effect of the initiating disturbance upon the frequency band generated leads to the conclusion that where the possibility of growth in time exists, a spatial discription of initial conditions gives rise to a broader band than does a temporal prescription. This is illustrated in specific cases. Previously suggested mechanisms for the conversion of these longitudinal oscillations into transverse electromagnetic energy are considered quantitatively and found to be inadequate. A more promising mechanism is suggested. A.

538.566 : 621.3.011 : 621.396.671

7113. Synthesis and analysis of elliptic polarization loci in terms of space-quadrature sinusoidal components. M. G. MORGAN AND W. R. EVANS. *Proc. Inst. Radio Engrs*, **39**, 552–6 (*May*, 1951).

The general case of elliptic polarization produced by three mutually perpendicular sinusoidal electromagnetic field components at a point in space is treated. The elliptic locus is specified in terms of the sinusoidal components and conversely the components are specified when the locus is known. The simpler two-component case is solved first. A.

538.566

7114. On the theory of electromagnetic wave diffraction by an aperture in an infinite plane conducting screen. H. LEVINE AND J. SCHWINGER. *Commun. Pure Appl. Math.*, **3**, 355–91 (*Dec.*, 1950).

A formal description of the fields on opposite sides of the screen and boundary conditions in its plan are given, based on symmetry properties of th Maxwell equations. To apply these b.c., expressio for the field vectors in any region are derived i terms of the tangential component of either E or on the boundary of the region. Mathematically th is obtained by means of tensor Green function Various stationary properties of the radiation fie are then established, from which the diffractio pattern may be obtained. One of them, derived fro an integral equation satisfied by the tangential com ponent of E on the aperture is of practical importanc at low frequencies, while one derived from th integral equation satisfied by the current distributio on the screen may be used at high frequencies. I the intermediate region the measure of agreemer between the results of the two methods allows a estimate of the degree of approximation. The metho is applied in detail to the case of a circular apertur with normally incident plane waves. L. PINCHERL

538.56

7115. On the theory of diffraction of e.m. wave H. SEVERIN. *Z. Phys.*, **129** (*No.* 4) 426–39 (1951) *German.*

The classical problem of the determination of a e.m. field in a given region from knowledge of th tangential component of either E or H on the boundar is solved by means of tensor Green functions.

L. PINCHERL

538.56

7116. Remarks on the optics of radio wave O. HALPERN. Letter in *Phys. Rev.*, **82**, 971–2 (*June* 1 1951).

The general criterion for an obstacle (e.g. a plan wall) of thickness d to be considered a minor dis turbance is $\pi\epsilon d/\lambda \ll 1$, where ϵ is the dielectr constant. L. PINCHERL

538.566 : 538.22

7117. A variational principle for the reflectio coefficients of the e.m. field. L. RONCHI. *Atti Fond "Giorgio Ronchi,"* **6**, 80–9 (*April*, 1951) *In Italian.*

A generalization of results given for the scalar cas by Toraldo di Francia [see Abstr. 6655 (1950)] Formulae are given which allow an approximat determination of reflection coefficients of plane e.m waves at stratified layers even when the solutions o Maxwell's equations are not known inside the laye L. PINCHERL

538.566 : 535.41

7118. Metal grid interference filter. E. A. LEWI and J. P. CASEY. Letter in *J. Opt. Soc. Amer.*, **41** 360 (*May*, 1951).

A technique for microwave interferometry i described. An interference filter has developed whic uses metal grids to replace the familiar absorbing A films. The absorption is less than that of the con tinuous film for corresponding reflectivity. A cross wave screen gives a reflectivity of 94% and the doubl screen filter has a band-pass width within 3% of tha computed for a grating of the same reflection, an passed 60% of the incident radiation, compared wit 0·02% for a corresponding continuous film.

S. TOLANSK

538.566

7119. On the waves guided by helicoidal circuits. E. ROUBINE. *C.R. Acad. Sci., Paris*, **232**, 1748–50 (*May* 7, 1951) *In French.*

The problem studied in previous papers [see Abstr. 3645 (1951)] is treated from a more general point of view. L. PINCHERLE

538.566 : 538.221 : 621.392.2 : 621.317.34

7120. Determination of the complex propagation constant on a Lecher system. A. WIEBERDINK. *Physica*, **17**, 333–8 (*March–April*, 1951).

A method is described by which the propagation constant of an electromagnetic wave existing on a Lecher system can be measured with great accuracy and with simple means. It has been applied to a concentric system, the central conductor of which was a nickel-iron wire (60% Ni, 40% Fe). A ferromagnetic resonance was found near a wavelength of about 95 cm and in the absence of a constant magnetic field. See also Abstr. 8861 (1950). A.

538.566 : 621.392.26

7121. On systems of linear equations in the theory of guided waves. W. MAGNUS AND F. OBERHETTINGER. *Commun. Pure Appl. Math.*, **3**, 393–410 (*Dec.*, 1950).

The diffraction of an electromagnetic wave between two parallel planes, or in a waveguide of rectangular cross-section, by a plane strip is investigated. The components of the diffracted wave can be expanded in a Fourier series. The Fourier coefficients are determined by an infinite system of linear equations. If the width of the diffracting strip is exactly one-half of the width of the waveguide, it is shown how the system of linear equations can be dealt with by a process of successive approximations, such that the first steps can be carried through explicitly.

K. JOHNSEN

538.566 : 621.392.26

7122. Wave propagation on helical wires. W. SOLLFREY. *J. Appl. Phys.*, **22**, 905–10 (*July*, 1951).

The field equations and boundary conditions are formulated exactly. They are then solved by an expansion in powers of the ratio of the thickness of the wire to the distance between turns. The method used consists of introducing a new co-ordinate system, which is such that a helical wire of circular cross-section is a surface in which one co-ordinate is constant. Maxwell's equations and the electromagnetic boundary conditions are expressed in terms of this system. Since nonorthogonal co-ordinates are involved, the equations cannot be solved exactly; but a perturbation procedure may be applied as indicated above. The result of the analysis is to show that there is a principal mode, which propagates with the free space velocity of light in the direction of the wire. The characteristics of this mode are studied, and they are compared successfully with experiment. A.

538.566 : 621.3.014.1 : 621.396.671

7123. Current and charge distributions on antennas and open-wire lines. D. J. ANGELAKOS. *J. Appl. Phys.*, **22**, 910–15 (*July*, 1951).

An experimental investigation has been made of the distributions of current and charge amplitude and phase on cylindrical aerials and on the driving lines. The presence of a stub support modifies the distributions on the aerial only near the junction of the aerial, line and stub; however, for aerial loads near anti-resonance, the distributions on the line as well as the impedances of the structure are altered considerably. A corrective network is defined for the terminal region of the junction. Impedances of theoretical models of aerials, the network and conventional transmission line equations may then be used to predict the apparent impedances of the structure. A.

538.566 : 621.396.671

7124. Radiation field of helical antennas with sinusoidal current. E. T. KORNHAUSER. *J. Appl. Phys.*, **22**, 887–91 (*July*, 1951).

A rigorous formula for the radiation field of a helical aerial is derived on the assumption of an empirical current distribution obtained experimentally by Kraus. For a helix of several turns this formula yields results very nearly the same as those obtained from an approximate method by Kraus, and it has the additional advantages of greater simplicity of computation and applicability to helices of non-integral numbers of turns. It appears that this empirical current distribution is of a most fortuitous form, but no theoretical basis for it has yet been found. A.

538.566.2 : 523.72

7125. The relativistic theory of electro-magneto-ionic waves. V. A. BAILEY. *Phys. Rev.*, **83**, 439–54 (*July* 15, 1951).

The relativistic equations governing an ionized gas pervaded by static electric and magnetic fields and the corresponding equations for small perturbations, are derived. The equations for plane perturbations are then obtained and several important cases are developed in detail. Frequency bands in which growing wavemodes occur are also determined. By means of certain rules of transformation the theory is also used to study the plane waves which can occur in interpenetrating double streams of electrons. The results obtained are formally similar to those obtained for waves in an ionized gas. In the absence of static magnetic fields and with the effects of collisions neglected it is found that, in either an ionized gas or in interpenetrating double streams of electrons, certain waves propagated obliquely to the drift motions may both grow and possess Poynting fluxes; these fluxes are such that certain initial disturbances can lead to the escape of amplified electromagnetic energy from an ionized medium. The exchange of momentum and energy, between the streams of electrons and ions and the growing waves, is discussed by means of the momentum-energy tensors of the charged particles and of the electromagnetic field. The results of the relativistic theory are then used to discuss briefly the problem of the origin of cosmic noise and of "isolated bursts" and "outbursts" of solar noise. It is concluded that both theory and observation lend support to the hypothesis suggested previously that a notable part of cosmic noise and strong solar noise originates as electro-magnetic-ionic waves in magnetized ionized regions. It would then follow that such regions occur in our Galaxy and in the Great Nebula in Andromeda. It is suggested that all "point sources" of cosmic

noise be examined for at least transient traces of the Zeeman effect and an excess of elliptically polarized noise. See also Abstr. 6212, 8018 (1950). A.

538.566.2

7126. Magneto-optics of an electron gas with guided microwaves. L. GOLDSTEIN, M. LAMPERT AND J. HENEY. Letter in *Phys. Rev.*, **82**, 956–7 (*June* 15, 1951).

Note on experiments in magneto-optic propagation in circular waveguide at 4 600–5 500 Mc/s employing as dielectric the decaying plasma from a pulsed d.c. gas discharge. Main results are: large angles of rotation (90° approx.) per λ; departure from linear polarization near resonance; demonstration of an analogue, for guided microwaves, of the crossed Nicol prism experiment. Z. F. WOJNAR

538.566.2 : 621.396.11

7127. Asymptotic solutions of a differential equation in the theory of microwave propagation. R. E. LANGER. *Commun. Pure Appl. Math.*, **3**, 427–38 (*Dec.*, 1950).

The differential equation is $U''+k^2[\Lambda+y(h)]U=0$, which is the equation found in the theory of microwave propagation in an atmosphere in which the index of refraction varies only with the height. Two different methods are used to find a solution according as the turning point is far from or near to the value of h which gives a minimum value for $y(h)$. In both cases asymptotic solutions for large k are found from known solutions of other differential equations. A qualitative comparison between the formulae derived and their analogues as obtained by power series methods is made, but no quantitative check is included.

K. JOHNSEN

538.566.2 : 551.594.6

7128. On "internal reflection" in a transparent medium with application to the troposphere. G. ECKART AND T. KAHAN. *Arch. Elektrotech.*, **40** (*No.* 2) 133–40 (1951) *In German.*

The problem of "internal reflection" in a transparent medium is considered and applied to estimate the field strength to be expected for echo sounding of the troposphere. For a standard atmosphere it is concluded that such echoes would not be observable above background noise and would only occur from dielectric constant gradients considerably in excess of normal values. W. J. G. BEYNON

538.566.3 : 551.510.535

7129. The theory of magneto ionic triple splitting. O. E. H. RYDBECK. *Trans. Chalmers Univ. Techn., Gothenberg, No.* 101, 38 *pp.* (1951).

Treats the theory of triple splitting of radiowaves incident normally on the ionosphere. An explanation is given of the dependence of this phenomenon on geomagnetic latitude. The rare cases of splitting at low geomagnetic latitudes is explained in terms of a strong step-like increase in electron density.

J. M. HOUGH

538.566.3 : 551.510.535

7130. On the problem of "triple splitting" in the ionosphere. W. BECKER. *Z. angew. Phys.*, **3** (*No.* 3–4) 83–8 (1951) *In German.*

The magneto-ionic theory of radio wave reflection for frequencies in the neighbourhood of the gyro-frequency is discussed. It is shown that the "third component" sometimes observed, arises during the transition from quasi-longitudinal to quasi-transverse propagation, the transition corresponding to a critical value of the collisional frequency. W. J. G. BEYNON

538.566.3 : 551.510.535

7131. Polarization of the *Z*-trace. J. E. HOGARTH. Letter in *Nature, Lond.*, **167**, 943 (*June* 9, 1951).

Polarization measurements made near latitude 60°N on the Z trace (the third component sometimes observed near f_0F2) show it to be of the "ordinary" type, i.e. anticlockwise as viewed in the direction of propagation [Abstr. 6189 (1950)]. W. J. G. BEYNON

538.566.3 : 551.510.535 : 621.396.11

7132. Plasma resonance in ionospheric irregularities. N. HERLOFSON. *Ark. Fys.*, **3**, *Paper* 15, 247–97 (1951).

The theory of meteor ionization is reviewed, and the properties of the ionized trails produced by meteors are estimated theoretically. Theories for radio reflections from meteor trails are critically examined, and an accurate scattering theory is formulated. It is found that a narrow trail with high electron density will behave as a resonator and give a strong echo for waves polarized with the electric vector normal to the trail. There is no resonance, and a weaker echo, when the electric vector is parallel to the trail. The effect is due to space charge induced in the boundaries of the trail, as in the plasma resonance studied by Tonks and Langmuir. It is of decisive importance for meteor echoes on wavelengths of some metres. The predicted polarization is confirmed in laboratory experiments by Romell. Polarization measurements on radio echoes would be a crucial experiment for testing the existence of the predicted resonance in meteor trails. The effect is more important on longer wavelengths, and may cause the observed rise in the rate of meteor echoes between 4 and 8 m. The discussion is extended to other scattering centres in the ionosphere, and it is found that any small irregularity can show plasma resonance. It is pointed out that a moderate turbulence in the main ionospheric layers would produce resonators, which can contribute to the pronounced fluctuations observed in single ray fading. A.

538.566.3 : 551.510.535 : 621.396.11

7133. On the synchronization of ionospheric echoes in oblique incidence transmission. W. DIEMINGER. *Z. angew. Phys.*, **3** (*No.* 3–4) 90–6 (1951) *In German.*

The different methods of synchronization of echo signals in oblique incidence ionospheric radio propagation are discussed. Some results obtained using quartz crystal control units are briefly considered.

W. J. G. BEYNON

538.566.3 : 621.396.11

7134. Effect of the earth's magnetic field on group velocity and time of travel of radio waves in the ionosphere. H. POEVERLEIN. *Z. angew. Phys.*, **3** (*No.* 3–4) 135–43 (1951) *In German.*

Group velocities and equivalent paths for the ordinary and extraordinary waves are calculated for a linear ionization density and frequencies $>f_H$ on ray theory. It is shown that for equal heights of

reflection there is not much difference in group paths for the two waves, and the shape of the P'-f curves cannot therefore give any real check on the theory. Such a check is best obtained by comparing critical frequencies of the ord. wave at vertical and oblique incidence. Curves are given of group velocity against ionization density for the two waves with varying directions of magnetic field. F. T. FARMER

538.566.3 : 621.396.677.1

7135. A phase-comparison method of measuring the direction of arrival of ionospheric radio waves. W. Ross, E. N. Bramley and G. E. Ashwell. *Proc. Instn. Elect. Engrs*, *Pt III*, **98**, 294–302 (*July*, 1951). [*Paper No.* 1134].

The most convenient research method of measuring completely the direction of arrival of waves reflected at the ionosphere appears to be that in which the phase differences of the signals received in an assembly of aerials are measured. If two pairs of similar aerials erected on lines perpendicular to each other are used, two independent phase angles may be obtained from which both angle of elevation and azimuth may be deduced. The apparatus described uses spaced coaxial loop aerials at a separation of 100 m. The signals from the aerials in a pair are amplified by means of matched receivers. The phase difference between the output signals from these receivers is displayed direct on a c.r.t. as the angle of inclination of the trace. With pulsed signals emitted from a suitable transmitter and with corresponding timing equipment in the receiver, the individual rays making up the total ionospheric signal may be separated from each other. The apparatus covers the frequency band 4–15 Mc/s, and the r.m.s. error of phase measurement is about 1°. Site errors, however, set a more severe limit to the accuracy of the directional measurements than do instrumental errors, and over an oblique path corresponding to a range of 700 km, bearings can be measured with an accuracy of about 1° while the angle of elevation can be measured with an accuracy better than about 1½° so long as it exceeds 30°. These limitations mean that angles of elevation of E-layer reflections cannot be measured accurately at long range; it is possible, however, to obtain measurements of useful accuracy of the angle of elevation of F-layer reflections at ranges up to 1 000 km or more. Bearings can be measured accurately at all ranges and for all reflections. The apparatus has so far been used principally for the study of F-layer reflections. A.

538.569 : 621.317.38.029.6

7136. Absolute measurement of microwave power in terms of mechanical forces. A. L. Cullen. Letter in *Nature, Lond.*, **167**, 812 (*May* 19, 1951).

The power may be determined from a measurement of the force on a moveable part of a cavity resonator, matched to its feeds, together with observations on the standing waves in the input guide when the output is closed with a moveable piston. This latter is placed at two positions $\frac{1}{4}\lambda$ apart and the corresponding movement in the main adjustment needed to keep the standing wave pattern stationary is found. F. T. FARMER

MAGNETIC EFFECTS 538.6

538.61

7137. Observation of magnetic domains by the Kerr effect. H. J. Williams, F. G. Foster and E. A. Wood. Letter in *Phys. Rev.*, **82**, 119–20 (*April* 1, 1951).

Using a polarized light compensator, magnetic domains have been observed by means of the Kerr magneto-optic effect on surfaces perpendicular and inclined to the C axis of hexagonal cobalt. A. E. DE BARR

538.613 : 538.567

7138. Faraday effect of cm waves. Resonance phenomena. C. Ryter and R. Extermann. *Physica*, **17**, 440–5 (*March–April*, 1951) *In French.*

A study of the rotation, as a function of the magnetic field, of the plane of polarization of a 3 cm wave propagating in $MnSO_4 . 4H_2O$ in the form of a powder. Results are in agreement with the theory. L. PINCHERLE

538.615

7139. Optical methods for the study of magnetic resonance. A. Kastler. *Physica*, **17**, 191–204 (*March–April*, 1951) *In French.*

The methods used for the investigations of space quantization and the determination of atomic quantum numbers and nuclear spin (j, i, f) can be divided into magnetic, optical (including r.f. spectroscopy) and magneto-optical. The magnetic resonance r.f. methods belong to the magneto-optical class. The degree of polarization of resonance radiation and fluorescence radiation of atoms is directly connected to the Zeeman structure of the spectral lines involved and is very sensitive to the alteration of this structure caused by nuclear spin. This polarization is the result of a selective excitation of m-sublevels of the excited state by the exciting radiation. As magnetic resonance between these sublevels tends to equalize their populations it will cause a depolarization of the emitted radiation, and this effect permits optical detection of magnetic resonance of excited states. Magnetic resonance of the 6^3P_1 state of Hg has been detected in this manner. Optical excitation of atoms by non-isotropic radiation, especially by a parallel beam of circularly polarized light, gives a possibility of changing the populations of m-sublevels of the ground state or of metastable states, and by optical re-excitation of this state this dissymetry of population can be tested. As this dissymetry is destroyed by magnetic resonance this resonance can be detected optically. This optical method seems to be particularly suitable for the analysis of metastable states and the study of h.f.s. Zeeman patterns in weak fields. A.

538.65

7140. Magnetic effects of tension in weak magnetic fields. L. Lliboutry. *J. Phys. Radium*, **12**, 482–8 (*March*, 1951) *In French.*

Discusses an extension of a theoretical treatment due to Brown [Abstr. 2600 (1949)]; account is taken of (i) deviations from the Rayleigh law, (ii) variation with tension of the Rayleigh constants, (iii) irreversible

magnetic viscosity effects, (iv) different contributions from 90° and 180° domain boundaries.

E. P. WOHLFARTH

538.652

7141. New techniques and results in the measurement of magnetostriction. J. E. GOLDMAN. *J. Phys. Radium*, **12**, 471–5 (*March*, 1951).

An account of the use of electrical resistance strain gauges. Results are given and discussed for single-crystal specimens of 30% Co–Fe and of Fe–Si, and for various polycrystalline materials, mainly Fe–Si sheet steel specimens (Hipersil), having preferred crystal orientation. The relation between magnetostriction and order-disorder changes is also briefly discussed.

E. P. WOHLFARTH

538.653

7142. Changes of magnetic permeability of carbon steels and pure iron under tension in an alternating magnetic field of constant amplitude. A. LANGEVIN. *J. Phys. Radium*, **12**, 476–81 (*March*, 1951) *In French.*

Describes results of magnetic and mechanical measurements already published [Abstr. 2878 (1951)].

E. P. WOHLFARTH

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

7143. Some investigations in the field of the theory of solids. I. Linear chain of similar atoms. T. A. HOFFMANN AND A. KÓNYA. *Acta Phys. Hungarica*, **1** (*No.* 1) 5–35 (1951).

A linear chain built up of similar atoms is treated by the "linear combination of atomic orbitals" approximation of the molecular orbital method. The energy can be calculated in a simple way for a finite chain as well as for an infinite one. The wave function can also be calculated and conclusions are drawn therefrom for end effects, for instance for work function and dipole layer. A.

539.11

7144. On the theory of cooperative phenomena. T. TANAKA, H. KATSUMORI AND S. TOSHIMA. *Progr. Theor. Phys.*, **6**, 17–26 (*Jan.–Feb.*, 1951).

The low temperature expansions of partition functions are obtained for several crystal types by direct counting of complexions and the typical cooperative phenomena are discussed. (1) Spontaneous magnetizations of the 3-dimensional Ising ferromagnets (in case of the simple cubic, the body-centred cubic and the face-centred cubic) are given. (2) Using the grand partition function for the face-centred cubic lattice, the properties of the regular solution are discussed. A condition for the appearance of an upper or a lower consolute temperature is obtained, taking account of the effects on free volume of each molecule due to the species of the nearest neighbour molecules. (3) Consideration of the regular solution as a mixture of holes and molecules leads to the properties of liquid. (4) Using the grand partition function for the triangular lattice, the adsorption phenomenon is discussed as the localized monolayer. A.

MOLECULAR STRUCTURE 539.13

539.13

7145. On the method of determining vibrations of polyatomic molecules. P. G. MASLOV. *J. Exp. Theor. Phys., USSR*, **20**, 609–18 (*July*, 1950) *In Russian.*

A technique is developed of finding the interaction coeffs. from observed vibration spectra of nuclei. The method of combined steepest descent is effective for solution of ∞ equations. J. JACOBS

539.13

7146. Determination of the duration of the excited oscillatory state by means of M. L. Veingerov's spectrophone. B. I. STEPANOV AND O. P. GIRIN. *J. Exp. Theor. Phys., USSR*, **20**, 947–55 (*Oct.*, 1950) *In Russian.*

In the chamber of the spectrophone temperature and thus pressure, pulsations are set up when the gas absorbs i.r. radiation entering the chamber in pulsed form. Every process of light absorption by a molecule causes a transition of the latter into an excited state of oscillation. If the probability of transition of oscillation energy into translation energy were infinitely great, the temperature rise would be instantaneous and simultaneous with the beginning of the irradiation. Correspondingly, the gas temperature would drop at the beginning of the dark pause. The actual form of the temperature variation is obviously different, because the variation becomes manifest only when an equilibrium state between light and dark periods has been reached. Nor is the probability of transition between oscillation and translation energy of the molecules infinite, and on the incidence of an exciting i.r. wave 3 processes are possible: (*a*) excitation of the molecule by the light; (*b*) inverse transition from excited into normal state with emission of a light quantum; (*c*) transition of oscillation energy into heat by non-elastic collisions with other molecules. A theory based on these assumptions is presented and the laws of heat production and variation in the spectrophone are derived. These are applied to measuring the lifetime of the molecule in the excited state. The results agree with Slobodskaya's measurements [*Izv. Akad. Nauk Ser. Fiz.*, **12**, 656 (1948)]. B. F. KRAUS

539.132

7147. Quadrupole resonance frequencies of Cl and Br nuclei in crystalline dichloroethylene and methyl-bromide. H. G. DEHMELT AND H. KRÜGER. *Z. Phys.*, **129** (*No.* 4) 401–15 (1951) *In German.*

Two absorption lines of polycrystalline trans-dichlorethylene were observed at 83°K at $(35{\cdot}480 \pm 0{\cdot}003)$, $(27{\cdot}963 \pm 0{\cdot}003) \times 10^6\ \text{sec}^{-1}$, each being attributed to a stable Cl isotope. The energy differences of the corresponding transitions are given by interactions of quadrupole moments of the nuclei with the inhomogeneous electric molecular field. Under assumption of equal fields the Q ratio is

$Q(Cl^{35})/Q(Cl^{37}) = 1{\cdot}2688 \pm 0{\cdot}0002$. The frequencies increase with temperature without affecting his ratio. For methylbromide $Q(Br^{79})/Q(Br^{81}) = 1{\cdot}1970 \pm 0{\cdot}0002$. J. JACOBS

539.132

7148. On the calculation of certain integrals occurring in the theory of molecules, especially three-centre and four-centre integrals. S. O. LUNDQVIST AND P.-O. LÖWDIN. *Ark. Fys.*, **3**, *Paper* 10, 147–54 (1951).

By using a method involving expansion in spherical harmonics, it is shown that a general formula can be reduced for the potential integrals, which occur in the theory of molecules and crystals. Explicit formulae are given for the 2-, 3- and 4-centre integrals of atomic S-functions. The method can be applied to analytical wave functions, but the formulae are more convenient for computations by means of numerical integration. A.

539.132

7149. Magnetic shielding of nuclei in molecules. N. F. RAMSEY. *Physica*, **17**, 303–7 (*March–April*, 1951).

An expression is developed for the magnetic field at a nucleus of a polyatomic molecule with zero resultant orbital and spin angular momenta in an external magnetic field. The field at the nucleus is not the same as the externally applied field because of the field arising from the motion of the electrons in the molecule. The expression for the electron contribution to the magnetic field is shown to consist of two parts, a simple term similar to the diamagnetic correction developed by Lamb for atoms and a complicated one arising from 2nd-order paramagnetism and analogous to the term dependent on the h.f. matrix elements in the theory of molecular diamagnetism. Under certain circumstances the latter term could become quite large. Since both of these terms are altered when the same nucleus is in different molecules, they at least partially and perhaps completely explain the chemical effect in nuclear moment measurements that has been reported by various observers. For linear molecules, the 2nd-order paramagnetism term is shown to be directly related to the experimentally measurable spin-rotational magnetic interaction constant of the molecule. This relation is particularly valuable in the important case of molecular H where it is shown that the correction for 2nd-order paramagnetism is $-0{\cdot}56\times10^{-5}$. When this is added to the Lamb type term as calculated by Anderson, the total magnetic shielding constant for molecular H_2 becomes $2{\cdot}68\times10^{-5}$. A.

539.132

7150. Interpretation of nuclear quadrupole couplings in molecules. W. GORDY. Letter in *J. Chem. Phys.*, **19**, 792–3 (*June*, 1951).

Coupling data can be explained by pure *p*-bonding orbitals for Cl, Br and I except when combined with C and F. J. JACOBS

539.132

7151. The intermediate spin-orbit coupling for large rotational quantum number. W. A. NIERENBERG. *Phys. Rev.*, **82**, 932–5 (*June* 15, 1951).

If a nucleus of spin one-half is cosine-coupled to the molecular rotation, its molecular beam spectrum can be predicted for all values of the magnetic field from the Zeeman to the Paschen–Back region with one closed expression. This expression is valid for large values of rotational quantum number and small rotational *g*-factor and is averaged over a Boltzmann distribution of rotational states. The special case of spin one-half is simple because the symmetry permits cosine coupling only, and the energy levels are well known for this Hamiltonian. A kind of correspondence principle can be developed for this example which does two things. It shows that the other nucleus in a diatomic molecule has little effect on the spectrum of the first because the coupling of the second nucleus due to the rotation. Second, it permits the extension of the calculation to nuclei of spins $>$ one-half when the coupling is predominantly cosinelike. A.

539.132

7152. Overlap and bonding power of 2*s*,2*p*-hybrid orbitals. R. S. MULLIKEN. *J. Chem. Phys.*, **19**, 900–12 (*July*, 1951).

A classification and nomenclature for $2s-2p$ hybrid *AO*'s (atomic orbitals) of any degree of hybridization is proposed, and the concepts of co-hybrids, antihybrids and orthohybrids are defined. Overlap integrals S as follows are computed and tabulated as a function of the hybridization coefficient and the interatomic-distance parameter for the case of two like first-row atoms: $S(h_\beta, h_\beta; \rho)$, $S(h_\beta, h_{0\beta}; \rho)$ and $S(1s, h_\beta; \rho)$. Here h_β denotes any $2s-2p$ hybrid, and $h_{0\beta}$ the corresponding orthohybrid. Slater *AO*'s were used, and also, for selected ρ values for the case of C–C bonds, *SCF AO*'s. Complete tables from $\rho = 3$ to $\rho = 14$, for the case of two like atoms, are given for the overlap integrals $S(1s, 2s)$, $S(2s, 2s)$, $S(1s, 2p\sigma)$, $S(2s, 2p\sigma)$, $S(2p\sigma, 2p\sigma)$ and $S(2p\pi, 2p\pi)$ using orthogonalized Slater $2s$ *AO*'s, and carbon *SCF* $2p\sigma$ and $2p\pi$ *AO*'s. Tables of Slater-*AO* overlap integrals $S(1s, h_\beta)$ are given as a function of β for the radicals FH, OH, NH and CH at their equilibrium distances, also similar tables based on *SCF AO*'s for the case of C–H bonds of lengths 1·12, 1·09 and 1·06 Å. A.

539.132

7153. Discrete energy levels associated with the Lennard–Jones potential. J. E. KILPATRICK AND M. F. KILPATRICK. *J. Chem. Phys.*, **19**, 930–3 (*July*, 1951).

The radial wave equation for two particles with a Lennard–Jones relative potential energy, in the reduced form, $-(R\psi)'' + 25b^2(R^{-12} - R^{-6})R\psi = -\lambda^2 R\psi$, has been examined for discrete eigenvalues by both variation and perturbation theory. The largest eigenvalue, λ_0 (corresponding to the lowest energy level), has been followed, as a function of b, until it disappears into the positive energy continuum, A short table of λ_0 and λ_1 has been computed. A.

539.132

7154. Centrifugal distortion in asymmetric top molecules. I. Ordinary formaldehyde, $H_2C^{12}O$. R. B. LAWRANCE AND M. W. P. STRANDBERG. *Phys. Rev.*, **83**, 363–9 (*July* 15, 1951).

A semi-classical approach is used to develop a simple expression for the centrifugal distortion correction in asymmetric top molecules. The general expression for the shift of any given energy level

involves five experimentally determined distortion coefficients and a knowledge of the dependence of the term value as a function of asymmetry. A useful simplified expression for the frequency correction in $\Delta J = 0$ transitions involves only two effective rigid rotor parameters and four distortion coefficients. The method is applied to the microwave spectrum of $H_2C^{12}O$; the results show excellent internal consistency. The resulting rigid-rotor parameters are: $a = 282\,106$, $b = 38\,834$ and $c = 34\,004$ Mc/s. The electric dipole moment is determined to be $2{\cdot}31 \pm 0{\cdot}04$ debye and the line breadth parameter as 97 ± 10 microns Hg per Mc/s. A.

539.132 : 535.343–14

7155. Molecular and nuclear magnetic moments in microwave Zeeman spectra. C. K. JEN. *Physica*, **17**, 378–85 (*March–April*, 1951).

Experimental data on the rotational moments of some polyatomic molecules are presented. Results of a quantum mechanical theory of the rotational moment in a symmetric top molecule are summarized. In the case of a nuclear coupling, the Zeeman spectra of the rotational fine-structure lines are analysable in terms of the combined effect of the nuclear and molecular (rotational) magnetic moments. Some new data on nuclear magnetic moments have been obtained by this procedure. A.

539.132 : 541.4

7156. Errata: Contributions to the theoretical treatment of ammonium. II. J. I. HORVÁTH. Letter in *J. Chem. Phys.*, **19**, 978 (*July*, 1951).

See Abstr. 2641 (1949).

539.132 : 541.57

7157. Factors affecting bond strengths. A. D. WALSH. **Comments:** H. W. LINNETT AND H. A. SKINNER. *Proc. Roy. Soc. A*, **207**, 13–32 (*June 7*, 1951).

I. A possible new definition of electronegativity.—It is proposed that the electronegativity of an atom or group A should be defined as the stretching force constant of the bond A–H, allowance being made in certain cases for repulsion between bond and lone pair electrons. The reasons for this proposal are set out and the resulting scale of electronegativities compared with the earlier scales of Mulliken and Pauling. Various applications, advantages and possible difficulties of the proposal are pointed out. A.

II. Empirical relations involving force constants and ionization potentials.—The following empirical relations are found. The force constant (k_e) of a diatomic hydride is roughly proportional to the square of the first ionization potential of the element forming the hydride. For a fixed element A and for B = F, Cl, Br or I, the plot of $k_e(A - B)$ versus $I(B)$ is linear. The slope of this line $(\partial k/\partial I)$ increases with increasing electronegativity of A. Similarly, the plot of $k_e(A - B)$ versus $I(B)$ is linear when A is a fixed group IV element and B = O, S, Se or Te; and the slope increases with increasing electronegativity of A. If A is a group IV element, B is a group VI element and B' is a group VII element of atomic number greater by unity than that of B, $k_e(A - B)$ is directly proportional to $k_e(A - B')$. The plot of $k_e(A - H)$ versus $I(A)$ is nearly smooth irrespective of the valency of A, but the plot of $k_e(A - O)$ depends markedly on the group number of A: it falls into a number of roughly straight lines each characteristic of a particular group or subgroup. The slope of these lines $(\partial k/\partial I)$ changes little from group III to IV but decreases markedly from group IV to V to VI. These relations supply abundant ways in which the force constants of bonds may be predicted. Tentative qualitative explanations are offered for some of them. A.

539.132 : 541.5

7158. The ionic character of bonds and bond properties. E. WARHURST. *Proc. Roy. Soc. A*, **207**, 32–49 (*June 7*, 1951).

The theory of ionic-covalent resonance has been outlined. It has been emphasized that the quantitative use of the theory necessitates assumptions which are not capable of general proof and that justification of the method rests mainly on the success achieved in the interpretation of experimental data. Several applications of the theory have been reviewed critically with particular reference to the nature of the assumptions involved. Conclusions concerning the present position of the theory have been made. A.

539.132 : 541.5

7159. Critical survey of the method of ionic-homopolar resonance. C. A. COULSON. **Comments:** W. MOFFITT. *Proc. Roy. Soc. A*, **207**, 63–74 (*June 7*, 1951).

Some of the theoretical difficulties are discussed. They include ignorance of the fundamental energies and also of the orbitals used. If these are hybrids, as usually occurs, considerable care is required in using the conventional theory because: (1) the atomic radius, and (2) the effective electronegativity of a hybrid depend on the degree of mixing of the basic atomic orbitals. In polyatomic molecules the lone-pair electrons play a substantial part in determining the total dipole moment, and there are further difficulties associated with (1) independence, (2) partial delocalization, and (3) possible "bent" character of the bonds. As a result many bonds (e.g. CH, NH, OH) are intrinsically much less ionic than is usually supposed. In addition the dipole moment of a molecule does not depend in any simple way upon the formal charges associated with the atoms; nor does it provide a completely satisfactory basis for assigning individual bond moments. A.

539.132 : 541.57

7160. The energies and bond lengths of conjugated molecules. An introductory review of theoretical developments. J. LENNARD-JONES. **Comments:** W. MOFFITT. *Proc. Roy. Soc. A*, **207**, 75–91, 100–11 (*June 22*, 1951).

The concept of the π-type of bond, introduced originally to explain the rigidity of the double bond of ethylene, forms the basis of the theoretical treatment of many of the properties of organic molecules. It has led to extensive calculations of energy contents and so of "resonance" energies. The percentage double-bond character and the lengths of carbon-carbon links have been deduced theoretically for a wide range of molecules and found to be in substantial agreement with X-ray measurements. Recently the theory has been developed to deal with the reactivities of conjugated molecules with promising results. The

successes and limitations of the present state of the theory are reviewed. A.

539.132 : 541.57

7161. Order/length relationships for π-bonds in heteronuclear molecules. E. G. Cox and G. A. Jeffrey. *Proc. Roy. Soc. A*, **207**, 110–21 (*June* 7, 1951).

For C–N and C–S bonds there are now enough experimental results to enable bond-order/length relationships to be proposed which can be used to correlate theoretical calculations of the distribution of π-electrons with experimental measurements of interatomic distances with sufficient accuracy to give critical guidance in further theoretical investigations. For these bonds, as for C–C bonds, consideration of π-bonding only accounts for much of the observational data relating to interatomic links intermediate in length between single and double bonds; the effects of hyperconjugation, polarity, hybridization and other environmental factors seem to be so small that they cannot be studied satisfactorily until an experimental accuracy of 0·01 Å or better can be obtained consistently. These remarks cannot be applied with the same certainty at present to C–O bonds where there is some evidence that environmental factors are more important. An interesting feature of recent work has been the accumulation of evidence that trigonal hybridization of atoms is more common than was supposed. A.

539.132 : 541.57

7162. Bond lengths in naphthalene and anthracene. C. A. Coulson, R. Daudel and J. M. Robertson. *Proc. Roy. Soc. A*, **207**, 306–20 (*July* 6, 1951).

An inquiry into the possibility of predicting bond lengths in condensed aromatic hydrocarbon molecules. Agreement with the best experimental values, such as those of Robertson, Abrahams, White, Mathieson and Sinclair, is fairly easily obtained to an accuracy of about 0·02 Å. This shows that the concept of fractional bond order may quite properly be used to infer bond lengths. Both the molecular-orbital and resonance methods are equally good for this purpose. Predictions to within less than 0·02 Å require the introduction of new factors usually neglected. Five such factors are discussed. Correction terms which result from these improvements lie between 0 and 0·015 Å, and are not all of the same sign. It is unlikely therefore that this type of analysis will be able to give confident predictions of bond lengths to less than 0·01 Å. A.

539.133

7163. The measurement of bond lengths in conjugated molecules of carbon centres. J. M. Robertson. *Proc. Roy. Soc. A*, **207**, 101–10 (*June* 7, 1951).

A review of recent theoretical and X-ray results for bond lengths in $C_{16}H_{10}$, $C_{24}H_{12}$, $C_{32}H_{14}$, $C_{10}H_8$, $C_{14}H_{10}$, stressing the extensive agreement. J. JACOBS

539.133

7164. Nuclear resonance in solid hydrocarbons. E. R. Andrew. *Physica*, **17**, 405–11 (*March–April*, 1951).

An investigation has been made of the variation with temperature of the proton magnetic resonance absorption line-width of 4 long chain aliphatic compounds and 8 aromatic hydrocarbons. The aliphatic compounds are dimorphous. In the lower temperature modification it is concluded that the molecules are rigid at 95°K, but that an increasing number of molecules rotate about their length as the temperature increases; it seems unlikely that rotational oscillation alone can account for the observed reduction of line-width as the temperature increases. In the upper temperature modification all the molecules rotate. A.

539.133

7165. Calculation of oscillator strengths for certain electronic transitions in B_2 and Na_2 G. Stephenson. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 425 (*April*, 1951).

In a one-electron approximation the 6 812 Å ($^1\Sigma_g^+ - {}^1\Sigma_u^+$) transition of Na_2 has $f = 0{\cdot}039$, the 3 271 Å ($^3\Sigma \quad - {}^3\Sigma_u^-$) transition of B_2 has $f = 0{\cdot}077$. J. JACOBS

539.133

7166. Internal rotation of methyl groups in cadmium dimethyl. D. R. J. Boyd, R. L. Williams and H. W. Thompson. Letter in *Nature, Lond.*, **167**, 766 (*May* 12, 1951).

The 5 cm^{-1} separation of Q-branches of the $\perp^r$ band at 2 980 cm^{-1} is evidence of free internal rotation about the Cd–C bond. J. JACOBS

539.133

7167. Dipole moment and ionic character. E. Warhurst and E. Whittle. Letter in *Nature, Lond.*, **167**, 767 (*May* 12, 1951).

The dipole moment of the HF bond cannot be explained solely in terms of *s-p* hybridization; ionic terms are needed in the wave function. J. JACOBS

539.133

7168. LCAO molecular orbital schemes and theoretical resonance energies. R. G. Parr. Letter in *J. Chem. Phys.*, **19**, 799–800 (*June*, 1951).

The error in orbitals and energy is assessed due to the use of an effective Hamiltonian only. J. JACOBS

539.133

7169. Orthonormal sets of LCAO molecular orbitals for second-row homopolar diatomic molecules. R. S. Mulliken. *J. Chem. Phys.*, **19**, 912–22 (*July*, 1951).

The forms of the LCAO MO's (molecular orbitals approximated by linear combinations of atomic orbitals) of any homopolar second-row diatomic molecule are studied under the restriction that they shall form an orthogonal set. The requirement of orthogonality *per se* causes $1s - 2s - 2p\sigma$ hybridization (forced hybridization) among the AO's (atomic orbitals) used in constructing the LCAO's. Equations, tables and figures are given showing how the degrees of hybridization in the members of mutually orthogonal sets of σ_g LCAO MO's, likewise of σ_u LCAO MO's, are related, as a function of two parameters: (*a*) assumed degree of hybridization in any one member of the set; (*b*) a parameter proportional to interatomic distance times effective nuclear charge. This is done using primarily Slater AO's, but the effect of using SCF (self-consistent-field) AO's is also studied. Assuming that overlap integrals are good measures of bond strengths, it is shown that the effect

of forced hybridization is to diminish bond strengths. It is concluded that this bond-weakening effect in LCAO MO valence theory is the counterpart of certain exchange repulsions which appear in the Heitler–London valence bond theory, namely those between bonding electrons on one atom and electrons in different (either bonding or lone-pair) AO's on the other atom. A.

539.133

7170. The overlap average and central field approximations. C. R. Mueller and H. Eyring. *J. Chem. Phys.*, **19**, 934–8 (*July*, 1951).

A series of approximations, which achieve a considerable simplification in molecular orbital calculations, is discussed. The method is to replace some of the more complex integrals in some cases by an "overlap average" of simpler integrals; in other cases to use a "central field" approximation. The effective charge of the central field point source is calculated by application of Gauss' theorem. These approximations are applied to diatomic lithium hydride. A.

539.133

7171. The dipole moments and structures of a series of alkyl polysulfides. C. C. Woodrow, M. Carmack and J. G. Miller. *J. Chem. Phys.*, **19**, 951–4 (*July*, 1951).

The dipole moments of *n*-hexadecyl mono-, di-, tri- and tetrasulphides at 30°C are 1·47, 2·00, 1·63 and 2·16*D*, respectively. These values provide evidence in favour of non-branched sulphur chains in the polysulphides and are also in accord with fixed non-planar configurations for these chains. It is possible that the disulphide exists as mixture of two nonsuperimposable mirror-image forms, the trisulphide as a mixture of one highly polar form together with a pair of nearly nonpolar enantiomorphs, and the tetrasulphide as a mixture of 3 different pairs of enantiomorphs, all 3 pairs being polar. A.

539.133

7172. A seemingly forbidden octacovalent structure. G. H. Duffey. *J. Chem. Phys.*, **19**, 963–4 (*July*, 1951).

About a metal atom in the $Ta_6Cl_{12}^{+a}$-like structure, one cannot set up *spd* hybrid orbitals directed towards all 8 neighbouring atoms. One can set up *spd* hybrid orbitals with 4 orbitals directed towards neighbouring halogen atoms and with 4 orbitals directed towards the middles of neighbouring faces of the octahedron. Using such bond orbitals in the over-all structure and assigning 2 electrons to each set of overlapping bond orbitals, one gets the value 2 for *a*. The degree of overlapping seems favourable. A.

539.133 : 535.343–14

7173. Erratum: Structure and dipole moment of isothiocyanic acid. C. I. Beard and B. P. Dailey. Letter in *J. Chem. Phys.*, **19**, 975 (*July*, 1951).

See Abstr. 2905 (1951).

539.133 : 535.343.4

7174. Pressure-induced absorption in hydrogen. J. van Kranendonk and R. B. Bird. Letter in *Phys. Rev.*, **82**, 964–5 (*June* 15, 1951).

Absorption due to one interacting pair of molecules is calculated by considering 0–1 vibrational transitions in one molecule, together with rotational transitions in either or both. J. JACOBS

539.133 : 535.343.4–1

7175. The microwave spectra and molecular structures of trifluorosilane derivatives. J. Sheridan and W. Gordy. *J. Chem. Phys.*, **19**, 965–70 (*July*, 1951).

Pure rotational spectra have been measured for the molecules $Si^{28}F_3H$, $Si^{29}F_3H$, $Si^{30}F_3H$, $Si^{28}F_3Cl^{35}$, $Si^{28}F_3Cl^{37}$, $Si^{28}F_3Br^{79}$, $Si^{28}F_3Br^{81}$, and $Si^{28}F_3CH_3$. Values of B_0 and moments of inertia, I_B, are tabulated. The nuclear quadrupole couplings of Cl^{35}, Br^{79} and Br^{81} in these molecules have been determined from their hyperfine structures as −43, 440 and 370 Mc/s respectively. Molecular dimensions, calculated by assuming the first parameter mentioned to be within the stated limits, are, for SiF_3H, $d_{SiH} = 1{\cdot}55 \pm 0{\cdot}05$ Å, $d_{SiF} = 1{\cdot}561 \mp 0{\cdot}005$ Å, $\angle FSiF = 108° 6' \mp 30'$; for SiF_3Cl, $\angle FSiF = 108° 30' \pm 1°$, $d_{SiF} = 1{\cdot}560 \mp 0{\cdot}005$ Å, $d_{SiCl} = 1{\cdot}989 \pm 0{\cdot}018$ Å; for SiF_3Br, $\angle FSiF = 108° 30' \pm 1°$, $d_{SiF} = 1{\cdot}560 \mp 0{\cdot}005$ Å, $d_{SiBr} = 2{\cdot}153 \pm 0{\cdot}018$ Å. The special shortness of silicon-halogen bonds is discussed and shown to be related to the electronic structure of silicon. The spectrum of SiF_3CH_3 shows lines caused by molecules in excited torsional vibrational states which show additional splitting caused by the doubling of the torsional vibrational levels. From relative intensities the height of the barrier opposing free rotation about the SiC bond is estimated as 1 200 cal/mole. From the variations of B_0 with torsional vibration, the separations of the doublets in the ground, first and second torsional vibration levels are estimated as $0{\cdot}1$ cm^{-1}, $1{\cdot}4$ cm^{-1} and 12 cm^{-1}, respectively. A.

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539.152.1

7176. The shell model of atomic nuclei. F. L. Bauer. *Phys. Bl.*, 7 (*No.* 5) 205–14 (1951) *In German.*

The evidence for the existence of "magic numbers" is summarized, and the current explanation in terms of the shell model with spin-orbit coupling is described. W. J. Swiatecki

539.152.1

7177. Multipole oscillations of the protons with respect to the neutrons in the liquid drop model of the atomic nucleus. M. Danos and H. Steinwedel. Note in *Z. Naturforsch.*, **6a**, 217–18 (*April*, 1951) *In German.*

Some refinements and extensions of the frequencies calculated by Steinwedel, *et al* [Abstr. 1235 (1951)]. W. J. Swiatecki

539.152.1

7178. On the addition energy for neutrons in the $h_{11/2}$ shell. A. C. G. Mitchell. Letter in *Phys. Rev.*, **83**, 183 (*July* 1, 1951).

The energy associated with the addition of neutrons to the $h_{11/2}$ state increases only slowly from N (no. of neutrons in nucleus) = 69 to $N = 77$, but increases rapidly from $N = 77$ to $N = 81$ as the shell becomes nearly filled. L. Pincherle

539.152.1 : 530.145

7179. Electromagnetic properties of nuclei and nuclear structure. L. ROSENFELD. *Physica*, **17**, 461–83 (*March–April*, 1951).

Regularities in the magnetic dipole and electric quadrupole moments of nuclei have made it possible to obtain a comprehensive view of nuclear constitution. A more quantitative examination of the e.m. interactions of nuclei with atomic and molecular fields yields valuable information on the spatial distribution of the constituent nucleons. In the case of the lightest nuclei a detailed analysis may be attempted of the ground state eigenfunction and of the interactions required to account for it. The main conclusion emerging from a treatment of these three aspects of the problem is that nuclear spin-orbit couplings are much stronger than the relativistic interactions of this type. The only type of meson field which may produce such a large spin-orbit coupling is a vector meson field with both vector and tensor coupling with the nucleons. The mesons corresponding to this field should have larger mass and shorter life than the π-mesons.

L. PINCHERLE

539.152.2

7180. On magnetic moments of nuclei. YU. A. ROMANOV. *J. Exp. Theor. Phys., USSR*, **20**, 577–83 (*July*, 1950) *In Russian.*

The nucleus interacts with the magnetic field due to a particle moving on the surface. The nucleus behaves like a superconductor and currents are set up producing an additional magnetic moment.

J. JACOBS

539.152.2

7181. Nuclear induction. F. BLOCH. *Physica*, **17**, 72–81 (*March–April*, 1951).

Establishment of suitable standards of comparison for the measurement of magnetic moments: While, until recently, the magnetic moment of the proton has been used as standard, there are now measurements carried out which give directly and with high precision the magnetic moment of the proton in units of the nuclear magneton; they are based upon the comparison of its resonance frequency with the orbital frequency of protons, circulating in the same magnetic field.

Application of nuclear induction to a great variety of different nuclei: The proper choice in the chemical composition of the sample is here of major importance in order to obtain suitable concentration, relaxation time and line width; particularly in cases where the nucleus possesses a large electric quadrupole moment, it is important to find a compound such that the broadening electric field gradients are greatly reduced by the symmetry of the molecule; it has been found, in this connection, that different compounds can lead to different resonance frequencies for the same nucleus, the largest differences, so far observed, being that of certain Co compounds and amounting to more than 1%. A.

539.152.2

7182. An experimental investigation of the nuclear magnetic moments of D^2 and H^1. G. LINDSTRÖM. *Physica*, **17**, 412–19 (*March–April*, 1951).

The magnetic moment of D^2 is measured against the magnetic moment of H^1 in two different chemical compounds (H_2O and paraffin oil) according to the resonance absorption method introduced by Purcell *et al.* The two samples are placed at different places in the magnetic field. The h.f. bridge with the H^1 sample is fed by 28 Mc/s from a frequency standard and the other bridge is fed from a heterodyne-frequency-meter, which is calibrated during the measurements against a 10 kc/s signal from the standard. With this arrangement it is possible to measure the frequency to the bridge with the D^2 sample with an accuracy of 1 part in 5×10^6. The two signals are photographed on a double-beam oscillograph. Pictures are taken with slightly different frequencies near the correct value and the measured differences are plotted against the frequency. The correct value can then be located with very high accuracy. The samples are changed and the measurements repeated. A.

539.152.2

7183. Determination of nuclear magnetic moments by super-regenerative techniques. D. WILLIAMS. *Physica*, **17**, 454–60 (*March–April*, 1951).

Electronic circuits oscillating under super-regenerative conditions have been used to observe nuclear magnetic resonances for twenty-three nuclear species. The circuits are described, and the nuclear *g*-factors and magnetic moments are given. The values for the nuclear magnetic moments have been determined in terms of the proton moment and are believed to be accurate to approximately one part in twenty thousand. A.

539.152.2

7184. Theoretical interpretation of the form of the nuclear resonance signals in the most general case. R. GABILLARD. *C.R. Acad. Sci., Paris*, **232**, 1477–9 (*April* 16, 1951) *In French.*

A new method of integration of Bloch's equations is given, based on a Fourier expansion. The solution accounts for the main aspects of the phenomenon in a perfectly homogeneous field. L. PINCHERLE

539.152.2

7185. Nuclear gyromagnetic ratios. III. R. E. SHERIFF AND D. WILLIAMS. *Phys. Rev.*, **82**, 651–5 (*June* 1, 1951).

See Abstr. 424 (1950) for Pt II. The super-regenerative oscillator techniques described earlier have been modified by introduction of a tuned narrow band amplifier with chart recorder and by improvements in magnetic-field regulation. Magnetic resonance frequencies of various nuclei have been compared with the resonance frequencies of H^1, D^2, Li^7 and Sc^{45}, which have been used as "standards." Ratios of the observed resonance frequencies to the proton resonance frequency in the same magnetic field are given for the following nuclear species: Be^9, B^{11}, F^{19}, Na^{23}, Al^{27}, P^{31}, V^{51}, Mn^{55}, Cu^{63}, Cu^{65}, Br^{79}, Br^{81}, Rb^{87}, Nb^{93}, I^{127}, Cs^{133}, La^{139}, Tl^{203} and Tl^{205}. The nuclear magnetic moments of these species have been determined in terms of the proton moment from the known spins and the observed frequency ratios after making diamagnetic corrections; values for the nuclear magnetic moments are listed. A.

539.152.2

7186. Hyperfine structure of Sm^{149}, Sm^{147}, Nd^{145} and Nd^{143}. K. Murakawa and J. S. Ross. Letter in *Phys. Rev.*, **82**, 967–8 (*June* 15, 1951).

Results: Sm^{149}, spin = 5/2, magnetic moment = $-0{\cdot}25 \pm 0{\cdot}04$ n.m.; Sm^{147}, $s = 5/2$, $\mu = -0{\cdot}30 \pm 0{\cdot}05$; $\mu_{147}/\mu_{149} = 1{\cdot}177 \pm 0{\cdot}015$; Nd^{145}, $s = 7/2$, $\mu = -0{\cdot}62 \pm 0{\cdot}09$; Nd^{143}, $s = 7/2$, $\mu = -1{\cdot}0 \pm 0{\cdot}2$; $\mu_{143}/\mu_{145} = 1{\cdot}60 \pm 0{\cdot}06$. L. PINCHERLE

539.152.2

7187. Spin of sodium-24. K. F. Smith. Letter in *Nature, Lond.*, **167**, 942–3 (*June* 9, 1951).

A magnetic resonance experiment has shown that the spin of Na^{24} is 4. L. PINCHERLE

539.152.2 : 539.153 : 539.181

7188. Hyperfine structure by the method of atomic beams. Properties of nuclei and of the electron. P. Kusch. *Physica*, **17**, 339–53 (*March–April*, 1951).

The fundamental experimental methods of molecular beams as applied to the observation of atomic hyperfine structure and its Zeeman effect are discussed, with emphasis on special techniques which have made it possible to obtain some of the recent important results derived from the observation of h.f.s. Among these are: (*a*) the determination of the nuclear spin of the radioactive isotopes Na^{22}, K^{40}, Cs^{135}, Cs^{137}; (*b*) the determination of the quadrupole moments of the nuclei Al^{27}, Cl^{35}, Cl^{37}, Ga^{69}, Ga^{71}, In^{113} and In^{115} from a measurement of the interaction energy of the nuclear magnetic dipole and electric quadrupole moments with the electron configuration and a prior knowledge of the magnetic dipole moment; (*c*) the investigation of the anomaly between the ratio of the observed h.f.s. splitting and the ratio of the magnetic moments of two isotopes. The anomaly has been observed for H, Li, K and Rb and its detection is possible only because of the very high precision with which the frequencies of lines in the h.f.s. spectrum may be found by use of the method of atomic beams. Important conclusions as to the structure of the nucleus are derived from the anomaly; (*d*) the precise determination of the magnitude of the anomalous spin magnetic moment of the electron, essentially by a measurement of the ratio of atomic *g* values for different electronic energy states. A.

539.153

7189. Effects of nuclear motion on the fine and the hyperfine structure of hydrogen. I. T. Ishidzu. *Progr. Theor. Phys.*, **6**, 48–60 (*Jan.–Feb.*, 1951).

The effects of nuclear motion on the energy levels of the hydrogen atom are studied by means of the relativistic 16-component wave equation. The work of Breit and Brown and of Breit and Meyerott is rearranged. It is shown that the original 16-component wave equation is reducible to a two-component radial equation in the special case where the total angular momentum $\boldsymbol{F}$ vanishes, and the latter equation is solved by expansion in power series in $\beta(= m/M)$. In general cases in which $\boldsymbol{F}$ is not zero, only expansion of the equation in power series in a^2 ($a = e^2/c\hbar$) enables the equation to be solved. This procedure is essentially equivalent to that of Bechert and Meixner, but the process of approximation seems to become clearer. The result for the correction due to nuclear motion on the fine structure is shown to be in close agreement with those of previous work. The correction factor for the hyperfine structure splittings is given by $(1 + \beta)^{-3}$ as usual for the two extreme hyperfine components $j = l + \frac{1}{2}$, $F = l + 1$ and $j = l - \frac{1}{2}$, $F = l - 1$, but is shown to be given by a new factor $(1 + \beta)^{-2}$ for the other two components $j = l \pm \frac{1}{2}$, $F = l$. Experimental proof of this factor would be very difficult, however, because the term responsible for this correction factor is absent in the energy expression for *s* terms, so that this appears only for the components of non-vanishing *l* terms. A.

539.153

7190. On the splitting of the ground state of Ni^{++} in Ni $SiF_6 . 6H_2O$. J. F. Ollom and J. H. van Vleck. *Physica*, **17**, 205–8 (*March–April*, 1951).

A summary is given of calculations on Ni fluosilicate which to a large extent reconcile the Stark splittings obtained from microwave spectra by Penrose and Stevens with the Faraday measurements of Becquerel and Van den Handel, and with the adiabatic demagnetization data of Benzie and Cooke. The reconciliation is achieved by including suitable amounts of isotropic and anisotropic exchange. On the other hand the case of the hydrated Ni sulphates is much less satisfactory. Calculations made by L. Corliss show that the model of the crystalline field employed successfully by Krishnan and by Polder for hydrated sulphates of Cu fails for those of Ni. A.

539.153

7191. Absolute oscillator strengths of chromium and nickel. F. B. Estabrook. *Astrophys. J.*, **113**, 684–9 (*May*, 1951).

By the method of total absorption, absolute *nf*-values have been obtained for the resonance triplet of Cr $a^7S_3 - z^7P^\circ_{2,3,4}$, respectively $\lambda\lambda$4290, 4275 and 4254. These do not agree with existing vapour-pressure data for Cr, but, using the best of such data available, the tentative assignment of absolute *f*-values for these transitions is: $f(4290) = 0{\cdot}0068$, $f(4275) = 0{\cdot}0097$, $f(4254) = 0{\cdot}0122$. Similar work on the Ni transitions $a^3D_3 - z^5F^\circ_4$ (λ3461·7), $a^3D_3 - z^3P^\circ_2$ (λ3524·5), and $a^3D_3 - z^3F^\circ_4$ (λ3414·8) corroborated the vapour-pressure data for Ni, and the absolute *f*-values for these transitions were found to be, respectively, $f(3461{\cdot}7) = 0{\cdot}0093$, $f(3524{\cdot}5) = 0{\cdot}0183$, and $f(3414{\cdot}8) = 0{\cdot}0171$, with a probable error of 10%. These agree well with the relative *gf*-values for Ni previously reported by R. B. King. A fit of his values to the new absolute values yields the factor $2{\cdot}55 \times 10^{-5}$, multiplication by which reduces any of the 134 relative *gf*-values for Ni transitions reported by King to the corresponding absolute *gf*-value. A.

539.153

7192. The use of calculated and observed energies in the computation of oscillator strengths and the *f*-sum rule. L. C. Green, N. E. Weber and E. Krawitz. *Astrophys. J.*, **113**, 690–6 (*May*, 1951).

The oscillator strengths or *f*-values for all transitions of importance from the 3*d* state of Ca II have been computed, using wave functions with and without exchange. Each value has been determined by the use of the calculated as well as the observed energies. The *f*-sum rule is well satisfied by the results with and without exchange if calculated energies are employed.

However, the f-values for particular transitions differ considerably. The meaning of the results is considered. The size of the total f-value for the $3d - f$ continuum appears to be even larger than was suggested by earlier work. A.

539.153

7193. A calculation of the electron affinity of sodium. R. M. THALER. *Phys. Rev.*, **83**, 131–3 (*July* 1, 1951).

A wave function of the form $\Phi = \phi(r_1, r_2)(1 + cr_{12})$ is assumed for the ($3s$) electrons of Na^-, to take into account the polarization effect of the added electron, an effect neglected by the Hartree method. On this basis the electron affinity of Na is calculated to be $+ 1{\cdot}2$ eV and therefore the negative ion is stable. The decrease in energy relative to the Hartree result is mainly due to the increased separation and consequent lowered interaction potential energy of the ($3s$) electrons. Since the ($4s$) electrons of K^- should be strongly polarized, the electron affinity of K can be estimated to be about $+ 0{\cdot}7$ eV. A.

539.153

7194. A note on atomic binding energies. L. L. FOLDY. *Phys. Rev.*, **83**, 397–9 (*July* 15, 1951).

By the use of Dickinson's recent calculations of the diamagnetic field for atoms, based on Hartree calculations, and a theorem due to Feynman, an expression is obtained for the total binding energy of the electrons in an atom as a function of atomic number. The results are compared with predictions of the Fermi–Thomas statistical model. It is found that the binding energy for small Z varies as $Z^{7/3}$ in accord with the statistical model but for high Z the dependence on Z becomes approximately $Z^{12/5}$. The equation for the binding energies is estimated to be correct to 5% or better. A.

539.153 : 538.221

7195. Interaction between the d-shells in the transition metals. III. Calculation of the Weiss factors in Fe, Co, and Ni. C. ZENER. *Phys. Rev.*, **83**, 299–301 (*July* 15, 1951).

For Pt II see Abstr. 5670 (1951). Estimates are made of the Weiss factors for Fe, Co and Ni using the author's previously proposed theory of indirect coupling via the conduction electrons. In this estimate use is made of only (i) the spectroscopic data for the coupling between the spin of the outer $4s$ electron and the spin of the inner incomplete $3d$ shell for the isolated atoms; (ii) the Hartree solution for the isolated Fe atom; (iii) the assumption that the conduction electrons behave as a free electron gas; (iv) the assumption that the direct coupling between adjacent d shells is negligible. The computed Weiss factors increase in the series Fe, Co, Ni in the same manner as do the empirical factors, but are somewhat larger. This discrepancy is in the right direction demanded by the previously proposed postulate that the direct interaction between adjacent d-shells always tends to an antiferromagnetic alignment. A.

539.153.4

7196. Electronic wave functions. IV. Some general theorems for the calculation of Schrödinger integrals between complicated vector-coupled functions for many-electron atoms. S. F. BOYS. *Proc. Roy. Soc. A*, **207**, 181–97 (*June* 22, 1951).

Pt III, Abstr. 4996 (1951). A scheme of theorems is developed which enables an important class of integrals of the Schrödinger Hamiltonian between antisymmetric vector-coupled functions of the Russell-Saunders type to be expressed in terms of integrals corresponding to smaller numbers of electrons. These integrals form the most important class occurring in problems of atomic spectra and the structure of atoms, but only particular reduction methods have been available previously. The analysis is based on the usual commutation properties of the angular operators, but some new formal rearrangements of the couplings within integrals are made, which give the essential reduction relations. The expansions are in terms of certain coefficients denoted by V and W, which must be evaluated numerically, but the particular values of which can be used repeatedly for unlimited numbers of special cases. These relations provide an important part of a general scheme of reduction of all Schrödinger integrals. A.

539.153.4

7197. Electronic wave functions. V. Systematic reduction methods for all Schrödinger integrals of conventional systems of antisymmetric vector coupled functions. S. F. BOYS. *Proc. Roy. Soc. A*, **207**, 197–215 (*June* 22, 1951).

Analyses on the expansion of equivalent electron functions, on changes in the order of vector coupling, and on the calculation of the V coefficients of Pt IV (previous Abstr.) are reported. These are of practical value, but their chief importance lies in the fact that they complete a series of theorems which makes it possible to formulate a general reduction scheme for all Schrödinger integrals between antisymmetric functions formed by the vector coupling of equivalent electron functions. This completes the derivation of the integral reduction methods required for the converging calculations of atomic wave functions. The methods will also be applicable to other problems at different levels of accuracy. A.

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16.08

7198. Absolute beta counting at defined geometries. G. I. GLEASON, J. D. TAYLOR AND D. L. TABERN. *Nucleonics*, **8**, 12–21 (*May*, 1951).

An improved form of absolute β-counting, using an end window G.M. tube, is described. In this method the counting geometry is fixed by means of a bevelled orifice in a brass plate, placed between the source and counter window so as to define accurately a cone of β-rays from the source which passes through the active volume of the counter. The determination of the correction for air and counter window absorption is discussed. The backscattering correction is reduced to $\sim 1\%$ by mounting sources on 0·001 in thick polystyrene. Experiments have shown that scattering from supports, orifice rim, etc., are negligible. Measurements on sources calibrated elsewhere by other methods gave excellent agreement.

L. R. SHEPHERD

539.16.08

7199. Radioactive standards and units. F. A. PANETH. *Nucleonics*, **8**, 38–41 (*May*, 1951).

Relates briefly the history of the definition of the Curie culminating in the adoption in 1950, by an international commission, of the definition that the unit represents the quantity of any radionuclide which undergoes $3{\cdot}700\times10^{10}$ disintegrations/second.

L. R. SHEPHERD

539.16.08 : 541.15

7200. Chemical dosimetry of ionising radiations. M. J. DAY AND G. STEIN. *Nucleonics*, **8**, 34–45 (*Feb.*, 1951).

Chemical methods give the amount of energy absorbed from ionizing radiations, in dilute aqueous solutions approximating to living tissues, in terms of measurable chemical reactions. In all cases, the primary effect is the ionization of the water molecules and the subsequent formation of free H atoms and OH radicals resulting from electron capture. A typical reaction, whose use is discussed, is the formation of phenol in dilute benzoic acid and sodium benzoate solutions, due to the action of the free OH radicals. A second type of reaction, which is considered, depends on the reduction of dyes, which results in observable colour changes. The dye may be dissolved in a gel (1–10% gelatine or agar in water) in which case the chemical products are confined for some time close to their points of formation and a 3-dimensional picture of dose distribution can then be obtained.

L. R. SHEPHERD

539.16.08 : 545.8

7201. A methane, proportional counting method for the assay of tritium. C. V. ROBINSON. *Rev. Sci. Instrum.*, **22**, 353–5 (*June*, 1951).

Radioactive water is reacted with methyl Grignard reagent to give radioactive methane, which is then admitted into a proportional counting chamber to be counted. Advantages of the method are convenience, absence of memory effects, linearity and a precision with a standard deviation $< 1\%$.

A.

539.16.08 : 615.849

7202. Dosage from radioisotopes uniformly distributed within a sphere. T. H. ODDIE. *Brit. J. Radiol.*, **24**, 333–6 (*June*, 1951).

Formulae are derived for the β- and γ-ray doses at points within and outside a sphere uniformly filled with radioactive material and of diameter comparable with the β-ray range. The results are expressed in terms of a factor which diminishes from unity with diameter of the sphere and distance of the point considered from its centre. The formulae are used to determine the effect of cellular concentrations of I^{131} in the thyroid.

F. T. FARMER

539.163

7203. Observations on radioactive snows at Ann Arbor, Michigan. W. W. MEINKE. *Science*, **113**, 545–6 (*May* 11, 1951).

Examination of the radioactivity after chemical separation, indicated that the activity originated in the Las Vegas atomic test explosions.

J. HUGHES

539.163

7204. Cross-over transition in the decay of Tc^{99m}. J. W. MIHELICH, M. GOLDHABER AND E. WILSON. Letter in *Phys. Rev.*, **82**, 972–3 (*June* 15, 1951).

A high-resolution 180° photographic β-spectrograph and Tc^{99m} from pile-produced Mo^{99} were used. $1{\cdot}4\%$ of the decay was found to be by 142·3 keV γ from the p 1/2 − to the g 9/2 + state, and $98{\cdot}6\%$ by $2{\cdot}0 \pm 0{\cdot}1$ keV γ to a 7/2 + state, followed by 140·3 keV γ.

F. R. HOLT

539.163 : 539.185

7205. The radioactive decay of the neutron. J. M. ROBSON. *Phys. Rev.*, **83**, 349–58 (*July* 15, 1951).

The protons from the radioactive decay of the neutron have been identified by measuring their charge-to-mass ratio with an electrostatic field and magnetic lens spectrometer. Coincidences have been obtained between these protons and the corresponding beta-particles from the neutron decay using a second magnetic lens spectrometer to measure the energies of the beta-particles. In this manner the beta-spectrum of the neutron has been measured over the region from 300 keV to the end point and has been found to be consistent with the energy distribution expected for an allowed transition. The end point of the spectrum is 782 keV with a probable error of ±13 keV. The half-life of the neutron is 12·8 min with a probable error of ±2·5 min.

A.

539.163.1

7206. Measurements on shortlived radioactive krypton isotopes from fission after isotopic separation. O. KOFOED-HANSEN AND K. O. NIELSEN. *K. Danske Vidensk. Selsk. Mat-fys. Medd.*, **26** (*No.* 7) 16 *pp.* (1951).

Gaseous Kr from the slow-neutron fission of U was separated isotopically in a mass-spectrometer and the short-lived activities of the deposits examined. The following $\frac{1}{2}$-lives were obtained: Kr^{89}, 3·18 min ($E\beta_{max} = 4{\cdot}0$ MeV); Kr^{90}, 33 sec (3.2 MeV, γ); Kr^{91}, 10 sec (3·6 MeV); Rb^{90}, 2·74 min (5·7 MeV, γ); Rb^{91}, 100 sec (4·6 MeV) and 14 min (3·0 MeV).

A. O. STANESBY

539.163.1

7207. The specific alpha-activity of U^{235}. E. H. FLEMING, JR., A. GHIORSO AND B. B. CUNNINGHAM. Letter in *Phys. Rev.*, **82**, 967 (*June* 15, 1951).

Thin uniform films of $99{\cdot}9\%$ U^{235} were counted in a calibrated medium geometry counter. A specific activity of $4\,774 \pm 72$ disintegrations/min/mg was found, corresponding to a half-life of $(7{\cdot}07 \pm 0{\cdot}11) \times 10^8$ years.

F. R. HOLT

539.163.2

7208. On the radioactivity of K^{40}. T. GRÅF. *Ark. Fys.*, **3**, *Paper* 13, 171–208 (1951).

Using a G.M. counter with an internal source, the branching ratio between electron capture and β-decay in K^{40} was measured. An upper limit of 0·2 was obtained for the γ/β ratio. A method of computing the efficiency of internal source counters for X-rays it outlined. Methods were evolved for improving upon, and checking the reliability of the counter operation in measuring small counting rate differences.

J. HUGHES

539.163.2

7209. Table of *ft* values in beta-decay. A. M. FEINGOLD. *Rev. Mod. Phys.*, **23**, 10–20 (*Jan.*, 1951).

Critical tables of ~ 520 β-decay half-lives, energies and $\log_{10} ft$ values based on the isotope compilation of Seaborg and Perlman [Abstr. 2054 (1949)] and subsequent literature up to June 1, 1950; ~ 230 refs.

W. J. SWIATECKI

539.163.2

7210. Highly forbidden transitions in the decay of Na^{24}. J. F. TURNER AND P. E. CAVANAGH. *Phil. Mag.*, **42**, 636–41 (*June*, 1951).

A description is given of the use of an organic scintillation counter in conjunction with a thin lens β-spectrometer to detect low-intensity, high-energy electron groups in the presence of a high background. Evidence for a 4·17 MeV β-group in the radiations from Na^{24} has been found, and a value of branching-ratio obtained. Measurements made on the secondary electron spectrum from Na^{24} show the presence of a high-energy γ-ray, possibly from the cross-over γ-transition in Mg^{24}. A.

539.163.2

7211. The application of proportional scintillation γ-ray counters to the determination of the decay scheme of Au^{198}. P. E. CAVANAGH. *Phys. Rev.*, **82**, 791–5 (*June* 15, 1951).

Besides the main γ-ray at 0·411 MeV, Au^{198} also emits two higher energy γ-rays of energy 0·67 and 1·09 MeV, present to the extent of only 1·4 and 0·4% respectively. Using large clear blocks of naphthalene + 1% anthracene as crude γ-ray separators, it has been established, by coincidence absorption measurements, that the high energy γ-rays are in coincidence with β-rays of maximum energy 295 keV. Moreover, it has been established that γ–γ coincidences also occur, and that the 0·67 MeV γ-ray is in cascade with the 0·411 MeV γ-ray. The 1·09 MeV γ-ray is not in coincidence with either of the others. By comparing the γ–γ coincidence rate and the β–γ coincidence rate taken under appropriate conditions, it was possible to determine branching ratios for the 0·67 and 1·09 MeV γ-rays. These are $(1{\cdot}43 \pm 0{\cdot}10)\%$, $(0{\cdot}33 \pm 0{\cdot}07)\%$ respectively, these results being in excellent agreement with those derived from spectrometer measurements. The β–γ and γ–γ coincidence measurements establish that Hg^{198} has energy levels at 0·411 and 1·09 MeV. A.

539.163.2

7212. The dual decay of Re^{186}. R. M. STEFFEN. *Phys. Rev.*, **82**, 827–31 (*June* 15, 1951).

The decay of Re^{186} (91 hr) has been investigated using spectrometer and coincidence methods. Two beta-groups with maximum energies of $1{\cdot}070 \pm 0{\cdot}005$ MeV and $0{\cdot}942 \pm 0{\cdot}008$ MeV have been observed. The lower energy beta-spectrum leads to an excited state in Os^{186} of 0·136 MeV energy. Nine % of all disintegrations are by *K*-capture; two-thirds of which lead directly to the ground state of W^{186} and one-third to an excited state of 0·122 MeV energy. Evidence is given for a spin 1 and odd parity of the ground state of Re^{186}. These assignments agree with the predictions of the one-particle spin-orbit coupling model extended to odd-odd nuclei. A.

539.163.2

7213. Radioactive decay of Cs^{137}. M. A. WAGGONER. *Phys. Rev.*, **82**, 906–9 (*June* 15, 1951).

The spins of the ground states of Cs^{137} and Ba^{137} are known to be 7/2 and 3/2 respectively. The shape of the 518 keV beta-ray spectrum has been measured and found to correspond to the correction factor $G' = (W_0 - W)^2 + A(W^2 - 1)$ in agreement with previous work. This is the shape predicted by the Fermi theory of beta-ray decay and the Gamow–Teller selection rules for a transition for which $\Delta I = \pm 2$ and there is a parity change. The internal conversion coefficient of the 663 keV gamma-ray has been measured and found to be 0·097, which is in agreement with the theoretical value for magnetic 2^4-pole radiation. A.

539.163.2

7214. Radiochemical and spectrometer studies of several neutron-deficient zirconium isotopes and their decay products. E. K. HYDE AND G. D. O'KELLEY. *Phys. Rev.*, **82**, 944–51 (*June* 15, 1951).

Radioactive Zr isotopes of mass number < 90 have been prepared by bombardment of niobium with 100 MeV protons. These isotopes and their decay products have been extensively studied in the beta-ray spectrometer and by radiochemical methods. Zr^{87} is shown to be a 94 ± 6 min activity emitting positrons of $2{\cdot}10 \pm 0{\cdot}02$-MeV energy and decaying into Y^{87m}. Accompanying its 14-hr decay into Y^{87}, Y^{87m} has a complex gamma-ray spectrum. The most prominent conversion electrons correspond to a $0{\cdot}389 \pm 0{\cdot}004$-MeV gamma-ray. Y^{87} decays by orbital electron capture into Sr^{87m} which isotope decays by emission of a $0{\cdot}394 \pm 0{\cdot}004$-MeV gamma-ray with a $2{\cdot}80 \pm 0{\cdot}03$ hr half-life into stable Sr^{87}. Zr^{86} is a 17 ± 2 hr orbital electron capturing isotope decaying into Y^{86}, which in turn disintegrates into stable Sr^{86} with a half-life of $14{\cdot}6 \pm 0{\cdot}2$ hr by the emission of positrons. This positron spectrum is complex, with two components of approximately equal intensity. The energies are $1{\cdot}80 \pm 0{\cdot}02$ and $1{\cdot}19 \pm 0{\cdot}02$ MeV. The latter appears to have a forbidden Fermi–Kurie plot corresponding to a first forbidden transition with a spin change of two units and a change of parity. The energy of the Zr^{89} positron is redetermined as $0{\cdot}910 \pm 0{\cdot}010$ MeV. Conversion electrons corresponding to previously unreported gamma-rays of energy 0·027, 0·396, 0·917 and 1·27 MeV are observed. Preliminary evidence for Zr^{88} is presented which indicates that this isotope decays, by the capture of orbital electrons with a half-life of the order of 150 days, into 105-day Y^{88}. Conversion electrons of a 0·406 MeV gamma-ray are prominent in the decay of Zr^{88}. A.

539.163.2

7215. The radioactive decay of Ca^{41}. V. L. SAILOR AND J. J. FLOYD. Letter in *Phys. Rev.*, **82**, 960 (*June* 15, 1951).

X-rays from pile-irradiated Ca have an energy of $3{\cdot}40 \pm 0{\cdot}15$ keV measured with a proportional counter spectrometer. They are probably potassium X-rays, and show that Ca^{41} decays by electron capture with a half-life of several months. F. R. HOLT

539.163.2

7216. The *L* to *K* capture ratio and disintegration energy of Sn^{113}. D. A. Thomas, S. K. Haynes, C. D. Broyles and H. C. Thomas. Letter in *Phys. Rev.*, **82**, 961–2 (*June* 15, 1951).

A counter of known sensitivities, a low-energy compensated magnetic lens spectrometer and a very thin source were used. The 85 keV transition reported by other writers was not observed and is shown to be energetically forbidden. The *L* to *K* capture ratio is deduced as 0·81 (or 0·31 to 1·43) and the disintegration energy to In^{113} (390 keV state) as 42 keV.

F. R. HOLT

539.163.2

7217. Scintillation studies of Os^{185}. M. M. Miller and R. G. Wilkinson. Letter in *Phys. Rev.*, **82**, 981 (*June* 15, 1951).

Using NaI–Tl crystals as detectors measurements were made of the γ- and X-ray spectra due to *K*-capture in Os^{185}. The accuracy of measurement of relative ray intensities was at least that of a normal magnetic-lens spectrometer. X-ray energies as low as 10 keV can be measured. G. F. J. GARLICK

539.163.2

7218. The disintegration of Nd^{147}. W. S. Emmerich and J. D. Kurbatov. *Phys. Rev.*, **83**, 40–3 (*July* 1, 1951).

Three groups of monochromatic electrons corresponding to gamma-rays of 91·5 ± 1·0 keV, 320 ± 3 keV and 534 ± 4 keV have been identified in the disintegration of Nd^{147}. These gamma-rays are ascribed to transitions in Pm^{147}. Evidence has been obtained for a complex beta-spectrum of Nd^{147}. On the basis of coincidences, a partial scheme of disintegration for Nd^{147} is proposed. The total energy decrease from the ground state of Nd^{147} to the ground state of Pm^{147} nuclei is 1·425 ± 0·015 MeV. A.

539.163.2

7219. The radiations from hafnium. S. B. Burson, K. W. Blair, H. B. Keller and S. Wexler. *Phys. Rev.*, **83**, 62–8 (*July* 1, 1951).

The 70 day, 45 day, 5·5 hr and 19 sec activities of Hf have been investigated by spectrometric, spectrographic, absorption and coincidence methods. From activation experiments on the separated Hf isotopes, the following assignments have been made: 70 day—$_{72}Hf^{175}$; 19 sec—$_{72}Hf^{179*}$; 5·5 hr—$_{72}Hf^{180*}$; 45 day—$_{72}Hf^{181}$. 70 day period.—The photographic spectrograms of the internal conversion electrons associated with the 70 day period in $_{72}Hf^{175}$ indicated the presence of 4 gamma-rays. The association of Lu work functions with the various lines confirmed the hypothesis of *K* electron capture in $_{72}Hf^{175}$ leading to an excited state of $_{71}Lu^{175}$. 45 day period.—An investigation of the internal conversion electron spectrum in the Argonne 180° beta-ray spectrometer indicated the presence of one beta-ray of 0·42 ± 0·01 MeV and 5 gamma-rays. An upper limit of 1% may be placed on any more energetic beta-ray. Single and coincidence absorptions in Pb and Al showed the 3 strongest gamma-rays and the single beta-ray. Delayed coincidence absorption indicated that the 0·42 MeV beta-ray leads directly to the 22 μsec metastable state of $_{73}Ta^{181}$. No delayed gamma-coincidences were found. Thus, all gamma-rays appear to follow the 22 μsec state. Additional coincidence measurements showed internal conversion electron groups corresponding to 3 of the gamma-rays. The decay scheme proposed by Chu and Wiedenbeck, as modified by Cork *et al.* was confirmed. 5·5 hour period.—Activation of extremely pure Hf samples showed an activity of 5·5 hr in addition to the 45 day period. The assignment of this activity to Hf was confirmed by chemical methods. No delayed coincidences were observed. Internal conversion electron groups corresponding to 5 gamma-rays were resolved; absorption in Pb indicated 3 of the photon components. Al absorptions indicated coincidences between internal conversion electron groups from at least 2 of the gamma-rays. Activation of separated isotopes shows that this activity is one of an isomeric state of $_{72}Hf^{180}$. 19 sec period.—A photographic spectrogram of the internal conversion electrons showed the presence of a single gamma-ray; the association of Hf work functions with the 4 lines observed verified the hypothesis of an isomeric state in $_{72}Hf^{179}$. A.

539.163.2

7220. Nuclear spectroscopy of Ba^{131} and Cs^{131}. R. Canada and A. C. G. Mitchell. *Phys. Rev.*, **83**, 76–9 (*July* 1, 1951).

The spectra of Ba^{131} and Cs^{131} have been investigated in a magnetic lens spectrograph. The 12 day Ba^{131} decays by orbital electron capture. Gamma-rays at 0·497, 0·371, 0·241, 0·213, 0·196 and 0·122 MeV have been observed. Cs^{131} (10 day) decays entirely by orbital electron capture. No gamma-rays are associated with this transition. In the particle spectrum only Auger electrons are found. There are no internal conversion lines which could arise from the 0·080 and 0·163 MeV states of Xe^{131}. It is concluded that Cs^{131} decays to the ground state of Xe^{131}. A.

539.163.2

7221. Dual decay of the 50-day In^{114} isomer and angular momenta of the excited states of Cd^{114}. R. M. Steffen. Letter in *Phys. Rev.*, **83**, 166 (*July* 1, 1951).

The In^{114} ground state is believed to be of even parity and to have $I = 1$. The isomeric transition (0·192 MeV, 50 day) is an electric 2^4-pole. The 50 day isomer also decays by *K*-capture direct to a 1·26 MeV Cd^{114} level, probably of odd parity. F. R. HOLT

539.164

7222. Investigations of the magnetic spectrography of α-particles of radioactive substances. Application to radiation of polonium and protactinium. E. Cotton. *Ann. Phys., Paris*, **6**, 481–560 (*May–June*, 1951) *In French.*

On the basis of the experimental curve of density variations of α-traces various distinct energy groups in the spectrum of the α-emitter were determined. The track-energy relations in known velocity regions were deduced; and a possible scheme of nuclear excitation levels of Ac is proposed from α-disintegration and known γ-radiation of Pa. J. JACOBS

539.164

7223. Complex alpha-spectrum of U^{235}. A. Ghiorso. Letter in *Phys. Rev.*, **82**, 979 (*June* 15, 1951).

A highly enriched 100 μg sample was collimated,

and observed with a 48-channel analyser. Three α-radiations were found: 10·2% at 4·58, 85·6% at 4·40, and 4·2% at 4·20 MeV. A subscript notation for the different transitions is suggested. F. R. HOLT

539.164

7224. Alpha-decay energies of polonium isotopes. D. G. KARRAKER, A. GHIORSO AND D. H. TEMPLETON. *Phys. Rev.*, **83**, 390–3 (*July* 15, 1951).

The isotopes Po^{200} and Po^{201} have been shown to have half-lives of 11 and 18 minutes, respectively, and to emit alpha-particles of 5·84 and 5·70 MeV. Both isotopes decay mainly by electron capture. The energies of the alpha-particles of the polonium isotopes 206 to 209 have been redetermined as 5·21, 5·10, 5·10 and 4·86 MeV, respectively. The abundance of the low energy alpha-group of Ra^{226}, which was used as a standard, was observed as 4·8% of the total alpha-activity. A.

539.165

7225. Properties of phosphorus-Bakelite beta-ray sources. O. M. BIZZELL, W. T. BURNETT, JR., P. C. TOMPKINS AND L. WISH. *Nucleonics*, **8**, 17–27 (*April*, 1951).

The properties, calibration and handling precautions of disk-shaped β sources, moulded from mixtures of equal parts of amorphous red phosphorus and Bakelite and irradiated by pile neutrons to produce 14·3 *d* P^{32}, are described. L. R. SHEPHERD

539.165

7226. The beta-ray spectrum of Tl^{206}. D. E. ALBURGER AND G. FRIEDLANDER. Letter in *Phys. Rev.*, **82**, 977 (*June* 15, 1951).

No γ-ray structure was found, and the (1·51 ± 0·01) MeV, 4·23 min β-decay is believed to be simple. F. R. HOLT

539.165

7227. The $H\rho$ of the high energy internal conversion electrons from thorium D. W. L. BROWN. *Phys. Rev.*, **83**, 271–4 (*July* 15, 1951).

The absolute $H\rho$ of the K internal conversion electrons from the 2·6 MeV gamma-ray of ThD has been measured using a 180° magnetic spectrometer whose field was calibrated with the proton magnetic resonance. With a proton resonance frequency, ν_P, of 3·75 Mc/s, corresponding to a field of 880 gauss and an electron radius, ρ, of 11·4 cm, the value $\nu_P\rho = 42{\cdot}528 \pm 0{\cdot}008$ cm Mc/s was obtained for the line. This is equivalent, through the proton gyromagnetic ratio, to an $H\rho = 9\,988._4 \pm 2$ gauss cm. A.

539.165 : 539.166

7228. Correlation between directions of a β-electron and a γ-quantum in successive emission. A. Z. DOLGINOV. *J. Exp. Theor. Phys., USSR*, **20**, 636–46 (*July*, 1950) *In Russian.*

This is examined for 5 variations of β-decay theory. A calculation is given for the 1st allowed and the 1st and 2nd forbidden β-transitions for a γ-quantum of arbitrary multipole. The influence of the Coulomb field on this correlation is investigated. J. JACOBS

539.165 : 539.166

7229. The radiations of UY (^{231}Th). P. H. STOKER, ONG PING HOK AND G. J. SIZOO. Letter in *Physica*, **17**, 164–6 (*Feb.*, 1951).

UY was examined in a semicircular focusing magnetic spectrometer; the β-spectrum is complex, with end-points at 390, 190 and 100 keV (relative intensities 1 : 2 : 2). Conversion lines indicate γ-rays of 59, 63, 82 and possibly 120 keV. A. O. STANESBY

539.165.08

7230. Determination of the energy distribution of β-spectra from an absorption measurement. H. SCHOPPER. *Z. Phys.*, **129** (*No.* 4) 416–25 (1951) *In German.*

The absorption law for homogeneous electrons is approximated by a parabolic function instead of the linear function used in earlier work. Graphs are given comparing the energy distributions calculated by this method with those obtained with a spectrometer for RaE, $UX_1 + UX_2$, P^{32}, $Sr^{90} + Y^{90}$. J. HUGHES

539.165.08

7231. A comparison of two methods for correcting for self-absorption of beta-particles, using sulfur^{35}. G. K. SCHWEITZER AND J. T. GARRETT. *J. Phys. Coll. Chem.*, **55**, 195–9 (*Feb.*, 1951).

Two methods used to correct for the variation in thickness (T) of the sample in routine assays of low-energy, β-emitting nuclides are: (*a*) plotting the observed activity (A) of a series of solid radioactive samples of const. specific A, but different T, against T and obtaining the exponential curve for the self-absorption of the radiation; the true A (i.e. which the sample would have if of zero T) is then obtainable by calculation from the A at infinite T as given by the flat portion of the curve; (*b*) the linear plot of the log of the observed A against T is extrapolated back to zero T. Results for the 2 methods are compared for the sulphates of Ba, Pb, Sr and benzidine, and agree within experimental error. Method (*b*) is the quicker, but requires many data at low surface densities.

J. GRANT

539.165.08

7232. Auxiliary equipment to be used with a beta-ray spectrometer for the study of radioactive gases. M. TER-POGOSSIAN, F. T. PORTER AND C. S. COOK. *Rev. Sci. Instrum.*, **22**, 389–92 (*June*, 1951).

A system is described whereby a gas may be circulated continuously between a cyclotron and a magnetic spectrometer of 14 cm radius of curvature. This apparatus does not modify the spectrometer itself but considerably increases its usefulness. Detailed descriptions are given of the chamber which is attached to the cyclotron for bombardment and of both beta- and gamma-ray source holders in addition to an overall picture of the entire system. A.

539.165.2

7233. Forbidden beta-ray spectra. A. M. SMITH. Letter in *Phys. Rev.*, **82**, 955 (*June* 15, 1951).

The cross-correction factors are given for first- and second-forbidden transitions, which arise through squaring of terms in the interaction, assumed to be a linear combination of the 5 relativistically invariant forms which have hitherto been used. L. PINCHERLE

539.165.2

7234. On the theory of beta-decay. R. J. BLIN-STOYLE AND J. A. SPIERS. Letter in *Phys. Rev.*, **82**, 969–70 (*June* 15, 1951).

The matrix elements of standard beta-decay theory are written in a new way which gives not only the

shape of the spectrum and the angular distribution for any degree of forbiddenness, but also the selection rules appropriate to any chosen type of interaction.

L. PINCHERLE

539.165.2

7235. A symmetry principle in the Fermi theory of beta-decay. G. L. TRIGG AND E. FEENBERG. Letter in *Phys. Rev.*, **82**, 982 (*June* 15, 1951).

Assuming the interaction to be a linear combination of the usual five relativistically invariant types, $V = G\sum_{k=1}^{5}[C_k V_k + C_k^* V_k^*]$, it is shown that, if the transition probabilities for positron and negatron emission are to be the same (neglecting the Coulomb field), then: $\varepsilon_k C_k^* = e^{i\theta} C_k$, where θ is an arbitrary phase and $\varepsilon_k = -1$ for scalar, axial vector and pseudo-scalar operators and $+1$ for polar vector and tensor operators. L. PINCHERLE

539.165.2

7236. The effect of finite nuclear size in beta-decay. M. E. ROSE AND D. K. HOLMES. Letter in *Phys. Rev.*, **83**, 190–1 (*July* 1, 1915).

Calculations based on Abstr. 5111 (1951). The effect on the wave function combinations L, M, N is demonstrated as a function of $Z(= 60, 83, 96)$, total energy of the β-particle (1–10 mc^2) and total angular momentum $k = 1, 2$ (small for $k \geqslant 3$); the effect decreases rapidly with increasing k, is only important for $Z > 60$, and is greatest for M, least for L, which implies an appreciable effect on β-decay only for forbidden transitions. A. O. STANESBY

539.165.8

7237. Maximum and mean energy of the recoil nucleus in the beta-decay of Kr^{89}. O. KOFOED-HANSEN AND P. KRISTENSEN. *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, **26** (*No.* 6) 20 *pp.* (1951).

For previous work on Kr^{88} see Abstr. 1291 (1947), 2555 (1948). The max. energy of recoil of the nucleus in the β-decay of Kr^{89} was 115 ± 5 eV, in agreement with the known value of $E\beta_{max}$; the average value of (recoil energy)/(charge on recoil atom) was 58 ± 2 eV/electronic charge. These results support forward neutrino emission, in agreement with the assumption that the transition is forbidden. The $\frac{1}{2}$-life of Kr^{89} was 3·14 min; the relative yields of mass numbers 89 and 88 in the slow neutron fission of U was determined as $y_{89}/y_{88} = 1{\cdot}5 \pm 0{\cdot}2$. A. O. STANESBY

539.166

7238. On the exchange effect of γ-rays with the deuteron. G. M. AVAKYANTS. *J. Exp. Theor. Phys., USSR*, **20**, 669–72 (*July*, 1950) *In Russian.*

Inclusion of the charge exchange between proton and neutron modifies considerably the effective cross-section of the deuteron splitting through γ-rays. J. JACOBS

539.166

7239. Angular correlation between the electron formed during pair conversion and the γ-quantum emitted during the subsequent nuclear transition. A. Z. DOLGINOV. *Dokl. Akad. Nauk, SSSR*, **77** (*No.* 2) 237–40 (1951) *In Russian.*

Matrix elements for magnetic or electric conversion transitions can be determined, whence the correlation follows for any multipoles of the 1st and 2nd transition. Example of dipole conversion transition with 2^L-pole radiation transition for electric and magnetic type. J. JACOBS

539.166

7240. Soft radiations from ^{239}Pu. D. WEST AND J. K. DAWSON. Letter in *Proc. Phys. Soc., Lond. A*, **64**, 586–7 (*June*, 1951).

Search was made for gamma-rays of ~ 50 keV [see Abstr. 6712 (1950)]. Most of the radiation was identified as U L-radiation [see Abstr. 3742 (1951)], but four weak rays were observed between 30 and 60 keV (intensities between 1 and 7×10^{-5} per alpha-particle); these may be due, however, to fission products in the Pu. All indications show that the gamma-ray is very highly internally converted.

539.166

7241. Diffusion of high energy gamma-rays through matter. III. Refinement of the solution of the diffusion equation. L. L. FOLDY. *Phys. Rev.*, **82**, 927–31 (*June* 15, 1951).

For Pt II, see Abstr. 4673 (1951). In the present paper, by consideration of the methods employed in obtaining the solution in II, a refinement of the solution is carried out which reduces the errors introduced by the approximations made both in the energy distribution and the angular distribution of the multiply-scattered gamma-rays. The solution is also modified to take into partial account the effect of small variations of the total gamma-ray cross-section with energy. An upper and lower bound on the solution is obtained when the cross-section is independent of energy. A.

539.166

7242. Gamma-rays emitted in the disintegration of the 36-hour Rh^{105}. C. E. MANDEVILLE AND E. SHAPIRO. Letter in *Phys. Rev.*, **82**, 953–4 (*June* 15, 1951).

Confirms a previously reported 0·3 MeV γ-ray accompanying about 8% of the β-rays. It is shown not to be a Bremsstrahlung effect. F. R. HOLT

539.166

7243. Angular correlation of successive gamma-ray quanta in Cu^{65}. T. WIEDLING AND A. CARLSSON. Letter in *Phys. Rev.*, **83**, 181–2 (*July* 1, 1951).

Measurements were made on the 2 cascade γ-rays of Cu^{65} (0·37 and 1·12 MeV) using anthracene scintillation counters and a resolving time of $\sim 0{\cdot}10$ μsec. Preliminary results indicate that the γ-rays are dipole-quadrupole, and that the spins of the excited states of Cu^{65} are 7/2 and 5/2.

A. O. STANESBY

539.166

7244. A high energy γ-ray line in the spectrum of Mg^{24}. L. E. BEGHIAN, G. R. BISHOP AND H. HALBAN. Letter in *Phys. Rev.*, **83**, 186 (*July* 1, 1951).

This was found at $3{\cdot}7 \pm 0{\cdot}1$ MeV using an ionization chamber. An upper limit of 2×10^{-6} photons/disintegration was also established for the 4·14-MeV cross-over line. See Abstr. 5242 (1950).

W. J. SWIATECKI

539.166

7245. Continuous γ-radiation of β-emitters. L. MADANSKY AND F. RASETTI. Letter in *Phys. Rev.*, **83**, 187 (*July* 1, 1951).

Results of experiments on P^{32} and RaE agree with

the theory of Knipp and Uhlenbeck [*Physica* **3,** 425 (1936)]; Bloch [*Phys. Rev.*, **50,** 272 (1936)]; Wang Chang and Falkoff [Abstr. 465 (1949)].

W. J. SWIATECKI

539.166 : 539.163.2

7246. Gamma-transitions in the disintegration of cerium 144. W. S. EMMERICH, G. JOHN AND J. D. KURBATOV. Letter in *Phys. Rev.*, **82,** 968 (*June* 15, 1951).

Internal-conversion electrons from Ce^{144} were examined in a permanent magnet spectograph calibrated against I^{131}, and γ-ray lines ascribed to Pr^{144} as follows:—certain: $80{\cdot}2 \pm 0{\cdot}5$, $134 \pm 0{\cdot}5$ keV (K/L intensities $\simeq 7/1$); probable: 33·6, 41·0, 53·0, 94·8 and 99·6 keV. A tentative level scheme is suggested for Pr^{144}.

A. O. STANESBY

539.166.08

7247. Self absorption corrections for large gamma-ray sources. W. R. DIXON. *Nucleonics*, **8,** 68–72 (*April*, 1951).

Calculations are made for homogeneous, parallel radiation from uniformly distributed sources in simple geometric forms, viz.:—linear, cylindrical and spherical. No account is taken of internally scattered radiation which might reach the detector.

L. R. SHEPHERD

539.166.2

7248. Determination of the energy $h\nu$ of a γ-ray by absorption of photoelectric electrons. J. JACQUESSON AND A. LATASTE. *C.R. Acad. Sci., Paris*, **232,** 1822–4 (*May* 16, 1951) *In French.*

Use is made of the linearity of the absorption curve in Al) for monoenergetic electrons to deduce the energies of γ-rays (from Au^{198} and W^{187}) from the positions of discontinuities in its slope. [Abstr. 473 (1950)].

W. J. SWIATECKI

539.166.83

7249. The internal conversion coefficients. I. The *K* shell. M. E. ROSE, G. H. GOERTZEL, B. I. SPINRAD, J. HARR AND P. STRONG. *Phys. Rev.*, **83,** 79–87 (*July* 1, 1951).

The internal conversion coefficients for electric and magnetic multipole radiation have been computed for the *K*-shell in the relativistic case with the uncreened Coulomb field acting on the electron. The numerical results, which are obtained to 4-significant-figure accuracy, were computed on the automatic sequence relay calculator (Mark I) and are given here for 12 values of Z in the range $10 \leqslant Z \leqslant 96$ and 5 gamma-ray energies (between $0{\cdot}3\ mc^2$ and $5{\cdot}0\ mc^2$) for the first 5 electric and first 5 magnetic multipoles.

A.

539.166.83

7250. The theory of internal conversion. N. TRALLI AND G. GOERTZEL. *Phys. Rev.*, **83,** 399–404 (*July* 15, 1951).

The theory of the internal conversion process is presented on a firm quantum-mechanical foundation and in a form most convenient for calculations. The question of the correct gauge for the radiation potentials and the effect of the finite size of the nucleus in these potentials are considered.

A.

NUCLEAR REACTIONS 539.17

539.17

7251. Angular correlations in nuclear reactions. M. DEUTSCH. *Rep. Phys. Soc. Progr. Phys.*, **14,** 196–226 (1951).

Experiments involving the measurement of angular distributions and correlations of nuclear radiations are classified into 3 groups: (1) those involving conservation of momentum; (2) those testing laws of interaction; (3) those which study properties of nuclear states (energy levels). Most of the report is given to the third group. The elementary theory of angular correlations is presented, and experimental technique is described. Recent experimental results are discussed.

A.

539.17

7252. On the interpretation of resonance levels and their widths in terms of the scattering length and the effective range. T. TEICHMANN. *Phys. Rev.*, **83,** 141–5 (*July* 1, 1951).

The so-called effective range formula for nuclear scattering is deduced from the nuclear dispersion formalism for a fairly general class of potentials. It is shown that only in the case of zero angular momentum scattering is the angular momentum uniquely determined from the low energy variation of the cross-section. The relation between the scattering length and effective range on the one hand and the parameters of nuclear dispersion theory (resonance levels and reduced widths) is briefly discussed.

A.

539.17 : 530.145

Variational approach to nuclear reactions. *See Abstr.* 6751

539.172

7253. On the nucleon cascade with ionization loss. H. MESSEL. *Phys. Rev.*, **83,** 21–5 (*July* 1, 1951).

The fundamental equations for a nucleon cascade including ionization loss are given. Solutions satisfying the exact boundary conditions are found in a manner similar to that used by Bhabha and Chakrabarty for the electron-photon cascade. However, in the present treatment, 2nd-order equations are not resorted to and all 4 cases (protons producing protons and neutrons; neutrons producing protons and neutrons) are treated simultaneously. The results are given in tabular and graphic form and can be adapted easily to any specific problem. A number of examples showing the effect of ionization loss have been computed and the ratio of neutrons to protons given. The calculations are carried out using the cross-section formulated by Heitler and Jánossy.

A.

539.172 : 537.591.8

The nuclear interactions of cosmic rays. *See Abstr.* 7058

539.172

7254. Nuclear disintegration caused by cosmic-rays. Y. FUJIMOTO AND S. HAYAKAWA. *Progr. Theor. Phys.*, **6,** 96–111 (*Jan.–Feb.*, 1951).

The diffusion of the nucleon components through the atmosphere is investigated. They are classified into 3 groups according to their energy, and the

various properties of their nuclear interactions are discussed. A.

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 7057–8

539.172

7255. Interaction of μ-meson with matter. I. Nuclear excitation by electromagnetic interaction. T. MUTO AND M. TANIFUJI. *Progr. Theor. Phys.*, **6**, 27–36 (*Jan.–Feb.*, 1951).

The inelastic scatter resulting from the excitation of surface waves with $l = 2$ or 3 is evaluated for low energy μ-mesons up to 12 MeV. Results are given graphically, and are of order 10^{-25} to 10^{-24}cm^2. E. P. GEORGE

539.172.11

7256. Magnetic analysis of the B (α, p)C reaction. G. M. FRYE AND M. L. WIEDENBECK. Letter in *Phys. Rev.*, **82**, 960–1 (*June* 15, 1951).

Po alpha particles and a semicircular focusing magnetic spectrograph were used. NTA plates screened with collodion were exposed for up to 199 hours. Q-values measured were: for B^{10}, $\sim 3{\cdot}8$, $0{\cdot}24 \pm 0{\cdot}02$, and $-0{\cdot}22$ MeV; and for B^{11}, $0{\cdot}75 \pm 0\ 01$ MeV. F. R. HOLT

539.172.13

7257. The transmutation of N^{14} by protons. D. B. DUNCAN AND J. E. PERRY. *Phys. Rev.*, **82**, 809–13 (*June* 15, 1951).

The reaction $N^{14}(p, \gamma)O^{15}$ has been studied experimentally in the energy range 0·25 to 2·6 MeV, using protons accelerated by an electrostatic generator and observing the induced O^{15} positron activity. Excitation curves have been obtained from Be_3N_2 targets, N gas targets and a thin target formed by proton bombardment of a Cu foil in a N atmosphere. The experimental cross-section can be described by 9 resonances, whose parameters are given. The bearing of these results on the yield of this reaction at stellar temperatures is discussed. A.

539.172.13

7258. Neutron energy distributions in proton bombardment of Be and C at 100 MeV. D. BODANSKY AND N. F. RAMSEY. *Phys. Rev.*, **82**, 831–6 (*June* 15, 1951).

The energy distributions of neutrons emitted in the forward direction when Be and C targets are bombarded by 100 MeV protons were investigated. The neutron energy distribution was found from the range distribution of recoil protons from a polyethylene target, measured with a scintillation counter telescope. The distribution for Be was found to be peaked at about 93 MeV, while the distribution for C fell off rapidly above 70 MeV. The influence on the observed distribution of energy resolution effects, particularly those involving energy spread of the cyclotron proton beam, is discussed. A.

539.172.13

7259. The energy and angular distribution of the gamma-rays from the reaction $Li^7(p, \gamma)Be^8$. H. NABHOLZ, P. STOLL AND H. WÄFFLER. Letter in *Phys. Rev.*, **82**, 963–4 (*June* 15, 1951).

A thick Li target was irradiated with 440 keV protons, and γ's from the 17·6 MeV Be nucleus formed gave stars in nuclear track plates. A $C^{12}(\gamma, \alpha)2\alpha$ cross-section ratio of 4 : 1 for 17·6 and 14·7 MeV γ's was deduced, and a very weak 12·6 MeV γ-line was found. Previously reported asymmetry of the 14·7 MeV line is now shown to be erroneous. F. R. HOLT

539.172.13

7260. Excitation functions for proton reactions with sodium and magnesium. J. W. MEADOWS AND R. B. HOLT. *Phys. Rev.*, **83**, 47–9 (*July* 1, 1951).

Proton bombardment at energies up to 120 MeV have been carried out on the Harvard University cyclotron using targets of $Na^{23}NO_3$, $Mg^{25}O$, $Mg^{26}O$ and ordinary MgO. A stacked sample and absorber technique was employed, using the formation of C^{11} from interleaved polyethylene foils as a monitor. The internal scattered beam at about 180° from the scatterer and 1 in below the median plane was employed to give better energy resolution. Absolute excitation curves have been obtained for the reactions yielding F^{18} and Na^{24} from Mg^{25} and Mg^{26}, F^{18} from Mg^{24} and F^{18} and Na^{22} from Na^{23}. A.

539.172.13

7261. Angular distribution of protons from $Li^6(d, p)Li^{7*}$, Li^7. D. N. F. DUNBAR AND F. HIRST. Letter in *Phys. Rev.*, **83**, 164–5 (*July* 1, 1951).

The distribution of long- and short-range protons, simultaneously at 10 different angles between 13° and 167°, was obtained photographically using deuterons of 400, 600 and 800 keV. The results differ from those of Krone *et al.* [Abstr. 2036 (1951)] but are of the same form as those of Whaling and Bonner [Abstr. 8985 (1950)]. The angular momentum of Li^{7*} is probably $\frac{1}{2}$, rather than $\frac{5}{2}$ [Abstr. 7194 (1949)]. The angular distribution of α-particles from $Li^6(d, \alpha)He^4$ was also determined for $E_d = 200$–1 000 keV; it agrees with that of Heydenburg *et al.* [Abstr. 3929 (1948)]. A. O. STANESBY

539.172.13

7262. Low excited states in Li^6 and Be^9. C. P. BROWNE, R. M. WILLIAMSON, D. S. CRAIG AND D. J. DONAHUE. Letter in *Phys. Rev.*, **83**, 179 (*July* 1, 1951).

Protons from a cylindrical analyser were used in the reaction $Be^9(p, \alpha)Li^{6*}$. The α's were observed with a spherical electrostatic analyser. Energy levels of $2{\cdot}187 \pm 0{\cdot}009$ MeV for Li^6 and $2{\cdot}433 \pm 0{\cdot}005$ MeV for Be^9 were found. The ground state for Be^9 was taken as $2{\cdot}123 \pm 0{\cdot}004$ MeV. F. R. HOLT

539.172.13

7263. Nuclear electron pairs from $F^{19}(p, \alpha)^*O^{16}$. G. C. PHILLIPS AND N. P. HEYDENBURG. Letter in *Phys. Rev.*, **83**, 184–5 (*July* 1, 1951).

A thin target of CaF_2 was bombarded with protons of energy 0·65–2·0 MeV and the positron-electron pairs from the 6·05 MeV excited state of O^{16} detected by anthracene scintillation counters in coincidence with a resolving time of 10^{-8} sec. Resonances were obtained for $E_p = 710$ (width = 35), 842 (24), 1 130 (43), 1 236 (58) and 1 367 keV (26 keV). No resonance was detected at 730 keV. A search was made for possible γ-ray pairs, which are $<0{\cdot}5$ intensity of electron pairs. A. O. STANESBY

539.172.13

264. Energy level at 31 keV in Al^{28} from $Al^{27}(d, p)Al^{28}$ reaction. H. ENGE, W. W. BUECHNER, A. SPERDUTO AND D. M. VAN PATTER. *Phys. Rev.*, **83**, 31–3 (*July* 1, 1951).

The proton group previously assigned to the ground state of Al^{28} from the $Al^{27}(d, p)Al^{28}$ reaction has been found to be a doublet, the low-energy member of which is ascribed to an excited state at $31 \cdot 2 \pm 2 \cdot 0$ keV. The Q-value corresponding to the Al^{28} ground state has been measured as $5 \cdot 494 \pm 0 \cdot 010$ MeV. The Q-value corresponding to the ground state of Mg^{25} in the $Al^{27}(d, \alpha)Mg^{25}$ reaction is $6 \cdot 694 \pm 0 \cdot 010$ MeV, and the first excited level in Mg^{25} is at $0 \cdot 584 \pm 0 \cdot 006$ MeV. A.

539.172.13

265. Gamma-ray transitions in B^{10}. D. E. ALBURGER. Letter in *Phys. Rev.*, **83**, 184 (*July* 1, 1951).

A possible γ-ray of energy $1 \cdot 73$ MeV, suggested by the level scheme for B^{10} of Ajzenberg [Abstr. 4717 (1951)] was sought in the reaction $Be^9(d, n)B^{10}$; within the statistics of the experiment it was not found. A. O. STANESBY

539.172.3

266. Resonances in (γ, n) processes. M. DANOS. Note in *Z. Naturforsch.*, **6a**, 218–19 (*April*, 1951) *In German.*

Comparison of the Z-dependence of experimental cross-sections for the (γ, n) process for $17 \cdot 6$ and $4 \cdot 8$ MeV γ-rays from Li, with the theory of Abstr. 235 (1951). W. J. SWIATECKI

539.172.3

267. Relative photoneutron yields from the 330-MeV bremsstrahlung. K. M. TERWILLIGER, L. W. JONES AND W. N. JARMIE. *Phys. Rev.*, **82**, 820–2 (*June* 15, 1951).

Relative photoneutron yields were determined for 30 elements bombarded by the 330 MeV X-ray bremsstrahlung of the Berkeley synchrotron. The determinations were made at 90° to the beam axis with a paraffin moderated BF_3 proportional counter. Relative yields for elements above atomic number 30 were proportional to $Z^{1 \cdot 7}$. Yields for low Z elements show a correlation with the binding energy of the last neutron. Angular distributions of photoneutrons were briefly investigated, and a Pb transition curve for photoneutrons was run. A.

539.172.3

268. Production of protons by high energy γ-rays. E. LEVINTHAL AND A. SILVERMAN. *Phys. Rev.*, **82**, 822–6 (*June* 15, 1951).

The protons ejected from various nuclei by the gamma-ray beam of the 320 MeV Berkeley synchrotron have been studied with a proportional counter telescope system. The energy distribution of the protons from C, Cu and Pb from 7 MeV to 30 MeV at 90° was roughly proportional to $1/E^2$. The angular distribution was spherically symmetrical for 10 MeV protons and showed a pronounced forward maximum for protons of about 40 MeV. The cross-section per nucleus for the ejection of 20 MeV protons was found to be proportional to Z. The experimental results indicate that protons above 30 MeV arise primarily from the interaction of the γ-ray with some small subunit of the nucleus rather than through the formation of an excited compound nucleus. A.

539.172.3

7269. Na^{20} from the gamma-ray bombardment of NaF. R. K. SHELINE. Letter in *Phys. Rev.*, **82**, 954 (*June* 15, 1951).

A NaF cylinder bombarded with 76 MeV betatron γ-rays for 3 sec periods was observed with a Geiger counter for 5 sec periods. The half-life measured was $0 \cdot 23 \pm 0 \cdot 08$ sec, that of positron emission from Na^{20}, probably produced by the reaction $Na^{23}(\gamma, 3n)Na^{20}$. F. R. HOLT

539.172.3

7270. Photodisintegration of copper. P. R. BYERLY, JR AND W. E. STEPHENS. *Phys. Rev.*, **83**, 54–62 (*July* 1, 1951).

The energy and angular distributions of the protons, deuterons and alpha-particles and the energy distribution of neutrons emitted from Cu nuclei irradiated with the X-rays from a 24 MeV betatron were determined with the use of photographic emulsions. The yields of neutrons, protons, deuterons and alpha-particles were observed to be $3 \cdot 6$, $1 \cdot 07$, $0 \cdot 34$ and $0 \cdot 04 \times 10^6$ particles, respectively, per mole per Roentgen unit. A comparison of the neutron : proton yields and the energy distribution with the theoretical predictions of the statistical models and direct photoelectric action indicate that the photodisintegration of Cu consists mainly in the evaporation of nuclear particles from the excited nuclei. However, the large numbers of deuterons observed can only be explained by a different mechanism such as the "pick up" of a proton by an emerging neutron. About 10% of the neutrons and protons have energies greater than expected from evaporation. These are ascribed to a direct photoelectric effect. The observed angular anisotropy of these high-energy protons supports this interpretation. A.

539.172.3

7271. The photodisintegration of He^4 nuclei by X-rays from a 100-MeV betatron. E. R. GAERTTNER AND M. L. YEATER. *Phys. Rev.*, **83**, 146–50 (*July* 1, 1951).

The photodisintegration of He^4 nuclei has been studied in a cloud chamber, with a 100 MeV betatron as a source of X-rays. The predominant reactions observed are $He^4(\gamma, p)H^3$ and $He^4(\gamma, n)He^3$. The angles, θ, at which the protons from the (γ, p) reaction are emitted with respect to the X-ray beam are consistent with a $\sin^2 \theta$ distribution. The measured average energy of the X-ray photons producing the γ–p disintegration is approximately 27 MeV. The total integrated photodisintegration cross-section is $0 \cdot 1 \pm 0 \cdot 05$ MeV-barn; this value is based on an earlier determination of the absolute N cross-section, obtained by a direct comparison of the number of nuclear disintegrations with the number of positron-electron pairs produced in the gas in the cloud chamber. A.

539.172.3

7272. Erratum: Determination of the photo-nuclear cross sections $S^{32}(\gamma, d)P^{30}$, $S^{32}(\gamma, np)P^{30}$, and $P^{31}(\gamma, n)P^{30}$. L. KATZ AND A. S. PENFOLD. Letter in *Phys. Rev.*, **83**, 169 (*July* 1, 1951).

See Abstr. 4724 (1951).

539.172.3

7273. Resonance phenomena in (γ, n), (γ, p) and $(\gamma, 2n)$ reactions measured by the technique of simultaneous activation. R. SAGANE. Letter in *Phys. Rev.*, **83**, 174–5 (*July* 1, 1951).

Measurements were made of the saturation intensities of activities produced by simultaneous bombardment of different elements with X-rays of 10–61 MeV, compared with a tentative standard, Cu^{62}. Resonances were found in (γ, n) reactions (Cu^{62}: 18 ± 1; Cu^{64}: $17{\cdot}5 + 1{\cdot}5 - 0{\cdot}5$; Mo^{91}: 22 ± 3; C^{11}: 30 ± 4 MeV), a $(\gamma, 2n)$ reaction (Cu^{61}, $24{\cdot}5 \pm 2$ MeV) and a (γ, p) reaction (Na^{24}, 22 ± 3 MeV); also in $Pb^{204}((\gamma, \gamma)$ or $(\gamma, 2n)$, 29 ± 4 MeV) and $Tl^{206}((\gamma, pn)$ or (γ, p), $23{\cdot}5 \pm 2$ MeV).

A. O. STANESBY

539.172.3

7274. Nuclear gamma-absorption cross section of Cu^{63}. L. MARSHALL, A. H. ROSENFELD AND S. C. WRIGHT. *Phys. Rev.*, **83**, 305–7 (*July* 15, 1951).

The absolute intensity of the bremsstrahlung beam from 46 MeV electrons in the Chicago betatron has been determined. Copper foil was irradiated and its activity measured with a calibrated counter. The integrated cross-section for $Cu^{63}(\gamma, n)Cu^{62}$ was found to be $(0{\cdot}77 \pm 0{\cdot}15) \times 10^{-24}$ cm² MeV. A Victoreen thimble, surrounded by a $\frac{1}{4}$ in-thick Pb wall and inserted into the beam, measured one r per minute for every $2{\cdot}5 \times 10^{7}$ MeV cm^{-2} sec^{-1} of beam intensity. A.

539.172.3

7275. Photoproton emission. A. LUNDBY AND L. MARSHALL. *Phys. Rev.*, **83**, 323–5 (*July* 15, 1951).

Protons from (γ, p) reactions produced by betatron bremsstrahlung with a maximum energy of up to 50 MeV have been studied with a scintillation counter telescope. Activation curves in Al and Pb showed threshold and resonance characteristics similar to the corresponding curves for the photoneutron processes. The integrated (γ, p) cross-section in Al was found to be $\sim 10^{-62}$ MeV cm² for 50 MeV bremsstrahlung. For the eleven elements investigated the integrated cross-section was roughly proportional to the atomic number. Absorption studies of the protons revealed a high energy component extending up to about 20 MeV which amounted to a few % of the total number of protons emitted from Al and Pb. For 50 MeV bremsstrahlung the relative photoproton emission at 90° and at 120° to the X-ray beam was measured for Al and Pb. The protons above about 15 MeV were found to come out preferentially at 90° for both elements. A.

539.172.3

7276. Properties of (γ, n) cross sections. L. MARSHALL. *Phys. Rev.*, **83**, 345–9 (*July* 15, 1951).

The mean energies of photons producing the reactions $Cu^{63}(\gamma, n)Cu^{62}$, $Zn^{64}(\gamma, n)Zn^{63}$ and $C^{12}(\gamma, n)C^{11}$ have been found by measuring their absorption coefficients for many values of Z. Monitor and detector were made of the element investigated. The absorbers were Be, C, Al, Ti, Fe, Ni, Cu, Zn, Se, Mo and Sn. Less than 1% of the radiation striking the detector originated in the absorber. In this geometry, $(1/Z) \times$(absorption cross-section) was a linear function of Z. The Compton cross-section was separated from the pair cross-section by considering its different Z-dependence. The mean energy was evaluated in two ways: (1) from the observed pair cross-section and the Bethe–Heitler formula, and (2) from the observed Compton cross-section and the Klein–Nishina formula. A correction was applied for the deviation of pair cross-section from the value given by the Born approximation. With this correction, the values of the mean energy were found to be Zn^{64}, 16·6 MeV from Compton cross-section, 20·0 MeV from pair production; Cu^{63}, 17·3, 21·0; C^{12}, 23, 32 MeV. The integrated (γ, n) cross-section for C^{12} and Zn^{64} have been found to be $0{\cdot}086 \times 10^{-24}$ and $0{\cdot}77 \times 10^{-24}$ MeV cm², respectively.

539.172.

7277. Cross sections of gamma-proton reaction J. HALPERN AND A. K. MANN. *Phys. Rev.*, **83**, 370– (*July* 15, 1951).

Using the University of Pennsylvania betatron, th energy-dependencies of the γ–p cross-sections of C Al, Co, Ni and Cb have been measured. The cross-section curves exhibit the resonance character foun in γ–n reactions. The significant parameters of eac of the curves are tabulated. From these data and th known γ–n cross-section data, the sum of neutron an proton integrated cross-sections is evaluated fo C and Ni. A

539.172.3 : 537.533.

7278. An investigation of bremsstrahlung by mean of the nuclear isomerism of indium. II. E. J. SCHIL LINGER, JR., B. WALDMAN AND W. C. MILLER. *Phys Rev.*, **83**, 320–3 (*July* 15, 1951).

For Pt I see Abstr. 2650 (1949). A magneti deflection technique has been employed in a re investigation of the thin target X-ray excitation o In^{115}. The results of this investigation confirm the earlier results. Activation levels have been found a $1{\cdot}08 \pm 0{\cdot}02$, $1{\cdot}47 \pm 0{\cdot}02$ and $1{\cdot}60 \pm 0{\cdot}02$ MeV The latter level is reported for the first time. Above 1·65 MeV the increase in activity can be attributed to a rise in the isochromats and/or many unresolved levels of relatively small cross-sections. The over-all cross-section (per electron incident on a 30 mg/cm Au target) is approximately 10^{-34} cm² at 1·4 MeV. A

539.172.4

7279. Study of the reaction of thermal neutrons with boron. P. CÜER AND J.-P. LONCHAMP. *C.R. Acad. Sci., Paris*, **232**, 1824–6 (*May* 16, 1951) *In French.*

Li^7 and α's from the reactions $B^{10} + n \rightarrow Li^7 + \alpha$ (1·77$_9$ MeV) and $B^{10} + n \rightarrow Li^{7*} + \alpha$(1·47$_4$ MeV) as recorded in an Ilford E_1 + B emulsion are used to extend the range-energy relation to low energies. The ratio of the cross-sections of the two reactions (4·27 ± 0·15%) deduced from 31 000 tracks disagrees with the value 5·8 ± 0·1% of G. C. Hanna [Abstr. 2054 (1951)]. W. J. SWIATECKI

539.172.4

7280. Slow neutron cross-sections of zirconium and hafnium. P. A. EGELSTAFF AND B. T. TAYLOR. Letter in *Nature, Lond.*, **167**, 896–7 (*June* 2, 1951).

The total neutron cross-sections of zirconia and hafnia were measured between 0·05 eV and 10 eV

ing a crystal spectrometer, and between 0·003 eV nd 0·1 eV using a mechanical time-of-flight spectro-eter. The cross-sections of Zr and Hf are deduced.
J. THEWLIS

539.172.4

:81. The inelastic scattering of fast neutrons. L. A. GRACE, L. E. BEGHIAN, G. PRESTON AND H. ALBAN. Letter in *Phys. Rev.*, **82**, 969 (*June* 15, 1951).
The 2·5 MeV neutron cross-sections of Be, Cu, Cr nd Fe were investigated, and earlier results [Abstr. 74 (1950)] for F, Mg and S are revised. The Cu spectrum shows two components, the Fe spectrum least two. F. R. HOLT

539.172.4

:82. Production of iodine—132. E. W. WINSCHE, G. STANG, JR., AND W. D. TUCKER. *Nucleonics*, 14–18, 94 (*March*, 1951).
2·4 hr I^{132} is grown from 77 hr Te^{132}, a U fission oduct obtained by pile irradiation. The Te^{132} is ssolved in a eutectic mixture of Li and K chlorides nd is shipped in a special container with a built-in rnace capable of melting the eutectic and driving off ^{32} as required, air being pumped through the molten quid to carry away the I vapour. The only serious ntaminant is I^{131} and this is present only in very nall proportion especially if the molten parent is rged of I a few hours before collecting the sample.
L. R. SHEPHERD

539.172.4

:83. Nuclear compressibility and fission. W. J. WIATECKI. Letter in *Phys. Rev.*, **83**, 178 (*July* 1, 951).
Calculated corrections to the deformation energy a nucleus caused by compressibility and polariza-lity of nuclear matter could explain the observed symmetry of fission. W. J. SWIATECKI

539.172.4

:84. Photoneutron fission analysis for U-235 in gh purity U-238. R. L. MACKLIN AND J. H. LYKINS. *Chem. Phys.*, **19**, 844–5 (*July*, 1951).
The photoneutron method for the analysis of U^{235} high purity U^{238} is described. Special samples have een found to contain as little as 5 parts per million ^{235}. An upper limit for the thermal neutron fission oss-section of U^{238} can be set at 5×10^{-28} cm^2. A.

539.172.4 : 537.56

:85. On the ionization yields of fission fragments. . B. LEACHMAN. *Phys. Rev.*, **83**, 17–20 (*July* 15, 951).
The disagreement between the distributions in ssion fragment mass and ionization is attributed to a ariation in ionization yield with fragment mass and a dispersion arising from such effects as neutron coil and instrumental errors of ionization measure-ent. After the effects of dispersion in the available ata of fragments from U^{235} slow neutron fission are ken into account, the variation in ionization yield estimated from the remaining disagreement in istributions. For the most probable fission asym-etry, the energy-ionization ratio of light fragments found to be approximately 3·7% less than for heavy agments. A.

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

7286. Production of photons in the collision of nucleons. R. OEHME. *Z. Phys.*, **129** (*No.* 6) 573–610 (1951) *In German.*
Following on Heisenberg's work on the creation of mesons in such collisions [Abstr. 9010 (1950)] the spectrum of photons produced by the decay of the neutral π° mesons into 2 or 3 photons is calculated. Comparison with experiments at moderate energies shows that the relevant process is $\pi^\circ \rightarrow 2\gamma$ and hence the π° has spin O. Further, from the observed energy spectrum of photons produced in the upper atmosphere, it can be deduced that the π-meson production cross-section varies with the $-1\cdot6 \pm 0\cdot2$ power of the energy (centre-of-mass system). The radiations of the charged mesons and the bremsstrahlung of the nucleons are then treated. For high energies the yields are sensitive to the assumed spin of the charged π, being greater for spin 1 than for spin O. This may afford the basis of an experimental discrimination.
W. J. SWIATECKI

539.18

7287. Optical representation with neutral atoms. H. FRIEDBURG AND W. PAUL. *Naturwissenschaften*, **38** (*No.* 7) 159–60 (1951) *In German.*

539.18

7288. Total cross sections of π-mesons on protons and several other nuclei. C. CHEDESTER, P. ISAACS, A. SACHS AND J. STEINBERGER. Letter in *Phys. Rev.*, **82**, 958–9 (*June* 15, 1951).
Negative mesons from a cyclotron, defined with a time-of-flight telescope, were passed through an absorber and detected with a liquid counter. For 85 MeV mesons the hydrogen cross-section is $1\cdot33\times10^{-26}$ cm^2, obtained by C–CH_2 subtraction. Cross-sections for Li, Be, C, O. Al, Cu, Cd and Pb are geometrical. F. R. HOLT

539.18

7289. On the cross section for photomeson production. G. ARAKI. Letter in *Phys. Rev.*, **82**, 959–60 (*June* 15, 1951).
Theoretical energy dependence of cross-section and angular distributions at 250 MeV, calculated for pseudoscalar and scalar theories, are compared with experiments of Abstr. 2060 (1951). W. J. SWIATECKI

539.18

7290. Neutral mesons produced in the capture of π^- mesons in hydrogen. A. SACHS AND J. STEINBERGER. Letter in *Phys. Rev.*, **82**, 973 (*June* 15, 1951).
Cyclotron-produced mesons and 2 500 lb/in^2 cooled hydrogen were used. It is confirmed that some of the negative mesons coming to rest in the atomic orbits of H nuclei are converted into neutral mesons. F. R. HOLT

539.18

7291. Scattering of π-mesons by deuterium. S. FERNBACH, T. A. GREEN AND K. M. WATSON. Letter in *Phys. Rev.*, **82**, 980 (*June* 15, 1951).
Meson–neutron scattering cross-sections may be deduced from observable hydrogen and deuterium cross-sections. Impulse approximation is used to find experimental conditions where a knowledge of the phase factor is unnecessary. F. R. HOLT

539.18

7292. Cross section for production of charged π-mesons in C and H at 90° to a 381-MeV proton beam. M. M. Block, S. Passman and W. W. Havens, Jr. Letter in *Phys. Rev.*, **83**, 167 (*July* 1, 1951).

This was found to be $(5{\cdot}2 \pm 1{\cdot}3) \times 10^{-28}$ cm^2 steradian^{-1}/C nucleus for 20–120 MeV π^+, and the π^+/π^- ratio was 11 ± 3. (Photographic plate method.) W. J. SWIATECKI

539.18

7293. Analysis of charged meson production by protons. S. Passman, M. M. Block and W. W. Havens, Jr. Letter in *Phys. Rev.*, **83**, 167 (*July* 1, 1951).

Analysis of Berkeley 342 MeV energy data and experiments of preceding Abstr. suggests that the matrix elements for π^+ production in H and C are proportional to the meson momentum.

W. J. SWIATECKI

539.18

7294. An equivalence theorem in meson theory. K. V. Roberts. Letter in *Phys. Rev.*, **83**, 188 (*July* 1, 1951).

Concerns the results obtainable with certain alternative Lagrangians (distinguished by giving rise to 3- or 4-vertices in a Feynman–Dyson graph).

W. J. SWIATECKI

539.18 : 539.166

7295. An attempt to detect μ-meson pairs from 322-MeV bremsstrahlung. J. W. Mather, E. A. Martinelli and W. N. Jarmie. Letter in *Phys. Rev.*, **82**, 973–5 (*June* 15, 1951).

322 MeV synchrotron X-rays were used on Cu and CH_2 targets, observed with scintillation counter telescopes. The counts obtained were comparable with the calculated accidentals (10^{-9} to 10^{-11} pairs per equivalent quantum). F. R. HOLT

539.185

7296. The index of refraction for neutrons. D. Kleinman and G. Snow. Letter in *Phys. Rev.*, **82**, 952 (*June* 15, 1951).

Lippman and Schwinger's method is reported to yield, when applied to macroscopic models, formulae for the refractive indices of beams of particles (in particular, of neutrons). J. R. MADDOX

539.185

7297. Coherent neutron scattering cross-section of V^{51}. A. W. McReynolds and R. J. Weiss. Letter in *Phys. Rev.*, **83**, 171–2 (*July* 1, 1951).

Reflection of a thermal neutron beam 1′ wide at a glancing angle of $\sim 2{\cdot}5'$ from a mirror of V was investigated as a function of the pressure of N_2 surrounding it; zero reflection occurred for $P_{N_2} = 2\,310$ lb/in^2 and by comparison with the coherent scattering cross-section for N_2 ($\sigma_{coh} = 9{\cdot}1$ barns), that of V^{51} is $0{\cdot}028 \pm 0{\cdot}005$ barns (positive phase). The potential scattering radius, R, is then $6{\cdot}02 \times 10^{-13}$ cm [see also Abstr. 6744 (1950)].

A. O. STANESBY

539.185

7298. Small angle scattering of neutrons. R. J. Weiss. *Phys. Rev.*, **83**, 379–89 (*July* 15, 1951).

The differential and total scattering cross-sections have been calculated for slow neutrons impinging on crystalline spheres whose radii are $\gg$ the neutron wavelength. The results for the differential cross-section show that when the difference, ρ, between the neutron phase shift in traversing the particle diameter and the phase shift in traversing the same distance in vacuum is small, the result agrees with the Born approximation, while if ρ is large, the result agrees with that obtained by geometrical optics. Also, the total cross-section for ρ small is $\pi R^2\rho^2/2$ and for ρ large $2\pi R^2$, where R is the particle radius. Using the Oak Ridge reactor, the broadening of a neutron beam in traversing finely divided materials was measured as a function of neutron wavelength, particle size, and coherent scattering cross-section, and the results verified these considerations. A new method for determining coherent cross-sections of nuclei and the phases of slow neutron scattering was demonstrated through the use of a liquid of known index of refraction into which the finely divided materials were immersed. In this manner, the phases of Mo, Cb, Pd, Ru, Si, P and Te were shown to be positive. A.

539.185 : 531.5

7299. Gravitational acceleration of neutrons. A. W. McReynolds. Letter in *Phys. Rev.*, **83**, 172–3 (*July* 1, 1951).

A well-collimated horizontal beam of thermal neutrons was examined at a distance of 11·6 m from the exit slit by means of a BF_3 proportional counter with a narrow slit, with and without a BeO filter 25 cm thick in the beam to remove neutrons with energies $> 0{\cdot}016$ eV; a drop of $1{\cdot}22 \pm 0{\cdot}06$ mm in the positions of the maxima was obtained, giving a value of $g = 935 \pm 70$ cm/sec^2. A. O. STANESBY

539.185 : 537.311.3

Effect of fast neutron bombardment on the electrical properties of germanium. *See Abstr.* 6969.

539.185.08 : 537.54

Scintillating liquids as neutron detectors. *See Abstr.* 7036.

539.185 : 539.16

The radioactive decay of the neutron. *See Abstr.* 7205.

STRUCTURE OF SOLIDS 539.2

539.2

7300. The dualism of crystalline and amorphous states in the structures of high polymers. S. G. Lefèbvre. *Bull. Soc. Roy. Sci. Liège*, **20**, 205–6 (*March*, 1951) *In French.*

Qualitative account of the appearance of crystallization in rayon and rubber. J. R. MADDOX

539.2

7301. The properties of the interstitial compounds of graphite. I. The electronic structure of graphite bisulfate. G. Hennig. *J. Chem. Phys.*, **19**, 922–9 (*July*, 1951).

The electrical resistance, its temperature dependence, and the Hall coefficients of graphite bisulphate compounds have been determined at various oxidation stages. The measurements have indicated that the

)xidation removes electrons from a nearly full conluction band. Reduction of the lamellar bisulphate ompounds produces residue compounds which retain bout a third of the bisulphate ions and half the ulphuric acid originally present in the lamellar ompounds. The formula of the residue compounds s approximated by $C_n.HSO_4.4H_2SO_4$. The model f a hypothetical graphite which has lost electrons rom its conduction band, is approximated closely y these residue compounds, since the impurities are listributed in a state of high disorder. The lamellar ompounds, on the other hand, may distort the band tructure of graphite because they form a superlattice.

A.

539.21 : 548.7

Theory of the crystalline state. *See Abstr.* 7383.

539.215

302. The permeability of zirconium to hydrogen. R. B. Bernstein and D. Cubicciotti. *J. Phys. Coll. Chem.*, **55**, 238–48 (*Feb.*, 1951).

Presents the results of the measurements of the ate of permeation of H through Zr at elevated emperatures. It was found that the rate of flow of H decreased always with time, and that the decrease vas approximately exponential. The energy of ctivation, calculated from the temperature-depenlence measurements, was 65–85 kcal/mole. The flow ate was found to be proportional to the square root f pressure. F. LACHMAN

539.215

7303. Theory of grain boundary motion. R. Smoluchowski. *Phys. Rev.*, **83**, 69–70 (*July* 1, 1951).

The mobility of grain boundaries in metals is considered from a point of view similar to that used by Mott in his theory of viscosity of grain boundaries. By introducing a factor dependent on surface tension of the grain boundary and inserting the experimental ctivation energy, one obtains satisfactory agreement with experiment. A.

539.217

7304. Determination of phase boundaries in solid alloy systems by a diffusion technique. C. E. Ransley. Letter in *Nature, Lond.*, **167**, 814 (*May* 19, 1951).

The technique is particularly useful when the alloying elements are present in only small proportions, and is applied to investigating the equilibrium constitution of Al–Si–Fe alloys, containing 0·5% Fe and 0–0·75% Si, between 450° and 600°C. A. D. Le Claire

539.217

7305. Diffusion in solid sulphur. R. B. Cuddeback and H. G. Drickamer. Letter in *J. Chem. Phys.*, **19**, 790–1 (*June*, 1951).

A determination of the diffusion coefficient in crystals, using radioactive S, over the range 309–374°K, covering the transition temperature (orthorhombic to monoclinic) 368·5°K. The experimental results agree closely with calculations based on the formula of Boas and Fensham [Abstr. 3423 (1950)].

A. J. KENNEDY

539.217

7306. Measurement of carbon diffusion in metallic carbides. G. C. Kuczynski and R. Landauer. *J. Appl. Phys.*, **22**, 952–5 (*July*, 1951).

A method for measuring the diffusion coefficient of C in metallic carbides is proposed. The rate at which excess metallic inclusions are consumed by C diffusing in from a surface is used to indicate the extent to which diffusion has taken place. Conditions are derived under which the results are susceptible to simple analytic treatment. A.

539.217

7307. Erratum: Lattice and grain-boundary self-diffusion in silver. R. E. Hoffman and D. Turnbull. Letter in *J. Appl. Phys.*, **22**, 984 (*July*, 1951). See Abstr. 5815 (1951).

539.27

7308. Carbonization of organic objects by electrons. H. König. *Z. Phys.*, **129** (*No.* 5) 483–90 (1951) *In German.*

Electron microscope photographs and electron diffraction patterns of polystyrene latex spheres and thin collodion films are given to show that the carbonization of organic materials by intense electron bombardment is different from that caused by heating. H. J. H. STARKS

539.27

7309. Studies of thin films by electron diffraction. N. R. Mukherjee and O. Row. Letter in *J. Appl. Phys.*, **22**, 681–2 (*May*, 1951).

Describes a method for the preparation of samples for electron diffraction studies, under controlled conditions, enabling a greater number of diffraction rings and improved contrast to be obtained.

H. P. MYERS

539.27

7310. Fine structure of electron-diffraction spots due to particle shape and to the method of shadow-casting. G. Honjo and K. Mihama. Note in *Acta Cryst.*, **4**, 282 (*May*, 1951).

This is shown for cubic and hexagonal smoke particles (manganous oxide, zinc oxide) and particles with fibrous orientation (magnesium oxide).

C. TURNER

539.27

7311. Determination of specific surfaces by means of the electron microscope. R. Bernard, E. Pernoux and S. Teichner. *C.R. Acad. Sci., Paris*, **232**, 1927–9 (*May* 21, 1951) *In French.*

The specific surfaces of samples of wolframite ground in different ways are calculated from electron microscope measurements of the statistical mean diameter and compared with values obtained from measurements of the adsorption of N at − 195°C. Eight types of sample are examined and except for one, in which the method of grinding produced dendritic particles, good agreement is obtained.

J. THEWLIS

539.27

7312. Portrait shadow-casting. D. E. Philpott. Letter in *J. Appl. Phys.*, **22**, 982–3 (*July*, 1951).

Clearer electron micrographs with more even illumination are produced. Measurements of the specimen as well as its shadow are more accurate, and the specimen stability is excellent. The method requires no extra equipment and only one extra shadow-casting. A.

ELASTICITY . STRENGTH . RHEOLOGY 539.3/.8

539.31 : 548.0

7313. Elasticity of crystals. M. J. Laval. *C.R. Acad. Sci., Paris*, **232**, 1947–8 (*May* 21, 1951) *In French.*

A note stating certain results obtained from an atomic displacement treatment. In general, 45 elastic coefficients are required for a crystalline medium, and not 21, as derived by Voigt, but for the particular case of central forces between atoms, certain coefficients conform with those of Voigt, and the medium can be treated classically. A. J. KENNEDY

539.32

7314. The measurement of Young's modulus for ferrites. L. Weil and L. Bochirol. *C.R. Acad. Sci., Paris*, **232**, 1807–9 (*May* 16, 1951) *In French.*

Young's modulus for a mixed Ni/Zn ferrite has been determined by measuring the resonant frequency of radial oscillations in a ring. As the density of the specimen was less than the bulk density of the material it is expected that the value of Young's modulus found ($1{\cdot}17\times10^{12}$ c.g.s.) is less than the true value.

A. E. DE BARR

539.32

7315. The variation of the dynamic elasticity of polythene with strain. K. W. Hillier. *Brit. J. Appl. Phys.*, **2**, 167–70 (*June*, 1951).

The variation in the dynamic elastic modulus of polythene when filaments of the material were subjected to increasing tensile strain is described. The dynamic modulus was obtained from observed values of the velocity of propagation of longitudinal oscillations using several frequencies and at 4 temperatures. The results are discussed with reference to the structure of polythene filaments and the probable changes that occur on stretching. A.

539.32

7316. Viscoelastic properties of several high polymers. M. Horio, S. Onogi, C. Nakayama and K. Yamamoto. *J. Appl. Phys.*, **22**, 966–70 (*July*, 1951).

The viscoelastic properties of viscose monofils differing in the degree of orientation were measured by means of the vibrating reed method within the frequency range from 20 to 100 c/s. The frequency dependence as well as the orientation dependence of the modulus and viscosity coefficient were discussed and connected with the relaxation mechanism. It could be expected that the anomalous dispersion should occur at frequencies lower than 1 c/s and at high frequencies such as $10^4 \sim 10^6$ c/s, the former being due to the motion of secondary cross bonds permitting the chains to slip, and the latter to the motion of segments. In order to supplement the data which support this discussion, measurements were extended to Cellophane, films of cellulose acetate, and Celluloid, and also to films of synthetic high polymers such as Polycaprolactam and polyvinyl chloride. The latter two substances showed noticeably different dynamic properties from that of cellulose. A.

539.32

7317. Dynamic measurements of physical properties of pulp and paper by audiofrequency sound. M. Horio and S. Onogi. *J. Appl. Phys.*, **22**, 971–7 (*July*, 1951).

The dynamic Young's moduli of various types of paper were measured by the vibrating reed method. The Young's modulus of paper increases statistically at a rate approximately proportional to the square of its density. The modulus and density of paper increase with the degree of beating. The sulphite and sulphate fibres behave differently during beating. The angular dependence of Young's modulus, tensile strength, and elongation at break was analysed mathematically; and the results were verified by experiments. According to this theory, the mean value of Young's modulus and tensile strength of machine-made paper should be expressed by the geometrical mean of the values of the machine and cross directions, whereas the mean value of elongation can be given by the arithmetical mean. The removal of parenchyma cells is very effective in reducing the Young's modulus of dissolving pulp. The viscoelastic properties of paper were observed within the frequency range from 20 to 180 c/s. The dynamic modulus and mechanical loss factor of the sheets employed were found to be smaller than one-tenth of those of cellulose films. The interfibre deformation influences the dynamic properties of paper. A.

539.32

7318. Forced vibration of reed as a method of determining viscoelasticity. M. Horio and S. Onogi. *J. Appl. Phys.*, **22**, 977–81 (*July*, 1951).

The motion of a clamp-free reed excited by a sinusoidal displacement of the clamped end was analysed by rigorously solving the fundamental equation for vibration. The real and imaginary parts of the modulus are given in terms of resonant frequency and band width of the frequency curves. The results are compared with those of Nolle which were obtained in an approximate manner by introducing an equivalent electric circuit. As long as the mechanical loss tangent is smaller than 10^{-1}, as is the case in most high polymers, the practical error caused by the approximation is estimated to be insignificant. Nolle's network was interpreted from a purely mechanical standpoint by means of the fundamental equation for vibration. A.

539.32 : 537.312.9

7319. Poisson's ratio and electrical resistance. J. R. H. Coutts and J. A. V. Fairbrother. Letter in *Proc. Phys. Soc., Lond. B*, **64**, 530–1 (*June*, 1951).

If a wire is subjected to a stress its linear dimension and its electrical resistance change, and it should be possible to make use of the latter alteration to determine Poisson's ratio for the material. A method is described based on certain assumptions, and the results of its application to Cu, Ni, Ag, Au and Pt given in comparison to those of orthodox measurements.

539.373

7320. Branching of slip lines in alpha-brass. H. Czyzewski. Letter in *J. Appl. Phys.*, **22**, 846 (*June*, 1951).

This phenomenon and slip along a twin interface was observed on an electron micrograph of alpha brass

which contained annealing twins. Deformation was produced by abrasion with a diamond penetrator.

J. E. CAFFYN

539.373 : 548.24

7321. Yield phenomenon and twinning in α-iron. A. T. CHURCHMAN AND A. H. COTTRELL. Letter in *Nature, Lond.*, **167**, 943–5 (*June* 9, 1951).

Extends observations previously published on 0·02% C iron single crystals [e.g. Schwarzbart and Low, *J. Met.*, **1**, 637 (1944)] by measurements at − 77°C, at which the yield point becomes more marked, and at − 190°C, at which the yield phenomenon is replaced by deformation twinning, leading to cleavage fracture after < 3·0% extension. This latter was not reproducible with polycrystalline specimens which fractured at the grain boundaries. Crystals from which C and N had been removed deformed by slip instead of twinning, and were more ductile. The effects observed can be explained on the basis of the steep dependence of the upper yield stress on temperature.

A. J. KENNEDY

539.374

7322. The propagation of longitudinal waves of plastic deformation in a bar of material exhibiting a strain-rate effect. L. E. MALVERN. *J. Appl. Mech.*, **18**, 203–8 (*June*, 1951).

Solutions are given for an idealized flow law and compared with solutions based upon earlier theories which neglect strain-rate effect.

A.

539.374

7323. Anelastic effects arising from precipitation in aluminum-zinc alloys. A. S. NOWICK. *J. Appl. Phys.*, **22**, 925–33 (*July*, 1951).

Torsion experiments on an Al–Zn alloy (21 atomic per cent Zn) show that precipitation gives rise to large values of internal friction. After prolonged periods of ageing, which are sufficient to produce growth of the precipitate particles, the internal friction begins to decrease. The activation energy for the elementary process producing the anelastic behaviour is 23 kcal per mole. It is demonstrated, with the help of static measurements, that the curves of internal friction *v.* temperature do not show a peak but continue to rise indefinitely with increasing temperature. This behaviour cannot readily be interpreted in terms of the usual concept of a relaxation spectrum but requires a new concept of *coupled relaxations*. Metallographic examination of the specimens reveals that the observations of large internal friction are correlated with the occurrence of discontinuous precipitation. The observed anelasticity is interpreted in terms of the fragmentation of the lattice; i.e. the formation of an irregular network of shear-relaxing interfaces during discontinuous precipitation. It is demonstrated that in such a network the coupling, produced by an overlapping of regions within which shear stress is relaxed, makes possible a very large total relaxation. Additional measurements of elastic after-effect in the supersaturated solid solution permit the determination of the mean time of stay of atoms in this solid solution, between 52°C and 72°C, by the anelasticity resulting from pair reorientation. The results obtained are in excellent agreement with the conventional high temperature diffusion data and correspond to a heat of activation for diffusion of 25·4 kcal per mole.

A.

539.389 : 548.7

The production and detection of a non-equilibrium number of vacancies in a metal. See Abstr. 7384.

539.4.014

7324. The effect of additional binding forces, introduced after loading, in a visco-elastic solid. F. LÉVI. *C.R. Acad. Sci., Paris*, **232**, 1809–10 (*May* 16, 1951) *In French.*

The internal stress produced by these forces for homogeneous linear flow is deduced.

J. E. CAFFYN

539.4.014.13

7325. A theory of stresses in glass butt seals. H. RAWSON. *Brit. J. Appl. Phys.*, **2**, 151–6 (*June*, 1951).

A series of equations are derived which may be used for the calculation of the stresses in glass butt seals and three component graded seals between materials of differing expansion coefficients. Stress determinations were made by the photoelastic method and good agreement was found between the theoretical and experimental values.

A.

539.4.016

7326. On the recovery process of cold worked metals. H. KANZAKI. *J. Phys. Soc. Japan*, **6**, 90–4 (*March–April*, 1951).

Curves of specific heat against temperature for cold-worked specimens of Cu and Ag show two minima which, it is suggested, are related to two separate processes having different activation energies —lattice distortion and grain fragmentation. The treatment is based on the Eyring reaction-rate theory, and a quantity "energy concentration factor" is derived, the numerical value obtained for Cu being shown to be close to the value of a quantity (claimed to be comparable) derived from Koehler's [Abstr. 2226 (1941)] calculations of a circular dislocation centre in a 2-dimensional model.

A. J. KENNEDY

539.434

7327. Transient creep in pure metals. O. H. WYATT. Letter in *Nature, Lond.*, **167**, 866 (*May* 26, 1951).

Creep tests made within the range − 196 to + 170°C on polycrystalline Cu, Al and Cd, and also on Al with only a few grains per specimen, showed that at low temperatures the creep curve is given by $e = a \log t + c_2$, and at higher temperatures by $e = \beta t^{\frac{1}{3}} + c_1$. At an intermediate range of temperatures, which is lower for higher stress, the creep curve fits $e = a \log t + \beta t^{\frac{1}{3}} + c_3$. In these equations, e = strain, t = time in secs, and a, β and the c's are constants. β-flow is thought to be connected with recovery rather than strain-hardening.

A. C. WHIFFIN

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.115

7328. The stability of gaseous diatomic oxides. L. BREWER AND D. F. MASTICK. *J. Chem. Phys.*, **19**, 834–43 (*July*, 1951).

The instabilities of FeO, NiO, MnO and SiO_2 upon vaporization, and upper limits to the heats of dissociation of these oxides and SiO have been determined by effusion experiments. The data available in the literature have been treated to obtain the heats of dissociation, or the upper limits thereof, of the gaseous oxides SnO, ZnO, CdO, CuO, PbO, GeO and TiO. The linear Birge–Sponer extrapolation of vibrational levels appears to give correct dissociation energies for the fourth-group oxides. A.

541.124

7329. The effect of ultrasonics on the rate of phase change in organic substances. A. P. KAPUSTIN. *J. Tech. Phys., USSR*, **20** (*No.* 10) 1157–9 (1950) *In Russian.*

A study of the rate of phase change in thymol and benzophenone has shown that it is possible to control the kinetics of this process. A threshold value has been found to exist for the effect of ultrasonics on the boundary line of the melt/crystal system. It has also been found that new crystallization centres wander away from the boundary line. The rate of phase change in ultrasonic field has been measured. When the solidification is going on under an irradiation with sound waves, the "ingot" obtained is remarkable for its homogeneity. F. LACHMAN

541.124

7330. The kinetics of the oxidation of gaseous methyl ethyl ketone. I. J. BARDWELL AND C. HINSHELWOOD. *Proc. Roy. Soc. A*, **207**, 461–70 (*July* 23, 1951).

In the oxidation of gaseous butanone the reaction rate increases with time from an initially small value to a maximum. The growth of rate in the early part of the reaction is exponential in form. Analysis for ketone shows that the consumption of butanone runs closely parallel to the increase of pressure. During the induction period peroxides accumulate and the rate of reaction is proportional to peroxide concentration. The formation of peroxides is greatly accelerated by the addition of a trace of acetaldehyde. A.

541.124

7331. The kinetics of the oxidation of gaseous methyl ethyl ketone. II. J. BARDWELL. *Proc. Roy. Soc. A*, **207**, 470–82 (*July* 23, 1951).

The rate of oxidation of the vapours of the aliphatic ketones at 250°C increases in the order: acetone, butanone, 2-pentanone, 3-pentanone. In its kinetics the oxidation of ketones resembles that of paraffins. Chain branching is favoured by an increase of the pressure of the combustible substance but is retarded by O. The observed behaviour is accounted for by a reaction scheme involving degenerate branching by intermediate peroxides. A.

541.124

7332. A study on the development of the depolarizing and catalytic activity of the oxygen compounds of manganese. J. BRENET AND A.-M. BRIOT. *C.R. Acad. Sci., Paris*, **232**, 2021–3 (*May* 28, 1951) *In French.*

The effect of temperature at which a Mn depolarizer was subjected to heat treatment on its depolarizing and catalytic activity has been studied. An abrupt discontinuity of activity and electro-chemical potential has been found to exist for a temperature in the neighbourhood of 160°C. F. LACHMAN

541.124

7333. Reactions of the hydroxyl [radical]. A. H. W. ATEN, JR. *J. Chim. Phys.*, **48**, 231–2 (*May–June*, 1951) *In French.*

Review of theories relating to the formation of the hydroxyl radical in aqueous solutions. F. LACHMAN

541.124

7334. On the mechanism of indirect action. F. H. KRENZ. *J. Chim. Phys.*, **48**, 237–41 (*May–June*, 1951).

Discusses the "chemical-school" theory of indirect action, based on homogeneous kinetics, and that advanced by the physical school, comprising a treatment of the mechanism by non-homogeneous kinetics. A case is considered when the rate of diffusion of radicals is large compared to both their recombination and reaction with the solute, and the corresponding mathematical analysis based on the physical theory is carried out. F. LACHMAN

541.126

7335. Chemical ionization in flames. H. BEHRENS. Letter in *Naturwissenschaften*, **38** (*No.* 8) 187–8 (1951) *In German.*

It is suggested that the high concentrations of ions in flames might be explained by the reaction $A' + B' = AB^+ + e$, where A' and B' are excited atoms or radicals. F. LACHMAN

541.126

7336. Inflammability ranges of propane-air mixtures under reduced pressure. R. DELBOURGO AND P. LAFFITTE. Letter in *Nature, Lond.*, **167**, 985–6 (*June* 16, 1951).

These were determined for mixtures containing 0–12% (by vol.) of propane over the pressure range ~ 20–760 mm Hg. Three different oxidants were used: (*a*) $0_2 + 4N_2$; (*b*) $0_2 + 5{\cdot}6N_2$; (*c*) $0_2 + 9N_2$. Ignition by rapidly-repeated spark discharge gave a wider inflammability range than the classical single-spark range; the shape of the inflammability-range obtained suggests the existence of 2 different mechanisms of combustion. A. SCHOFIELD

541.127

7337. Photographic recording of an explosion wave formed outside a linear charge (h.e.). S. B. RATNER. *J. Tech. Phys., USSR*, **20** (*No.* 12) 1422–5 (1951) *In Russian.*

Two parallel overlapping glass plates a few cm apart were placed alongside a cylindrical explosive charge, the plane of the plates being inclined at about 30° to the charge axis. The light emitted by the detonating explosive was recorded by means of a rotating-drum camera. Intense light emission occurred from the detonation wave and from impact of the accompanying shock-wave on the glass plates. The time between emergence of light from the

explosive and from corresponding points on the plates may be estimated from the photographic records; the author uses such measurements to deduce the velocity and shape of the shock wave. It is found that for nitroglycerine and hexogen the shock velocity is between 2 500 and 4 000 m/sec and that the wave front is inclined to the normal to the charge surface by 10–30°, the direction of inclination being away from the point of initiation. From the fact that the shock-velocity remains nearly const. over a radial distance ≫ the charge radius, it is concluded that the shock front is composed of particles of undetonated explosive originating in a surface layer approx. 1 mm thick. A. SCHOFIELD

541.127

7338. Hydrogen-oxygen reaction at the second explosion limit. H. P. BROIDA. Letter in *J. Chem. Phys.*, **19**, 790 (*June*, 1951).

Egerton and Warren's conclusion that the second limit is independent of the size of an explosion-vessel coated with boric acid [Abstr. 2118 (1951)] is confirmed up to a much larger vessel size. The explosion limit in clean Pyrex vessels and in vessels coated with KCl is also discussed. A. SCHOFIELD

541.127

7339. Role of oxide composition in oxidation of nickel and cobalt. R. L. TICHENOR. Letter in *J. Chem. Phys.*, **19**, 796–7 (*June*, 1951).

541.127

7340. Rapid gas phase reaction between nitric oxide and ozone. H. S. JOHNSTON AND H. J. CROSBY. Letter in *J. Chem. Phys.*, **19**, 799 (*June*, 1951).

541.127 : 541.133

7341. Determination of reaction-rates by conductivity measurements. B. JONES AND D. J. WORSFOLD. Letter in *Nature, Lond.*, **167**, 1072 (*June* 30, 1951).

Rate constants of 2·89 and 12·1 are found for the reactions between *p*-chloro- and *o*-nitro-benzyl chloride respectively, and KI in acetone, by measuring the electrical conductivities of the reaction mixture during the interaction. These are in good agreement with the values of 2·80 and 11·4 obtained by the customary volumetric method, which is less simple and more tedious to carry out. H. H. HODGSON

541.127 : 541.62

Substituted stilbenes. Thermal isomerization. See Abstr. 7362.

541.127.1

7342. Fractionation of the carbon isotopes in decarboxylation reactions III. The relative rates of decomposition of carboxyl-C^{12} and -C^{13} mesitoic acids. A. A. BOTHNER-BY AND J. BIGELEISEN. *J. Chem. Phys.*, **19**, 755–9 (*June*, 1951).

The relative rates of decarboxylation of C^{12}- and C^{13}-carboxyl mesitoic acids have been studied at 61·2 and 92·0°c. The ratios of the rate constants at these temperatures are 1·037 ± 0·003 and 1·032 ± 0·001, respectively. A comparison is made with similar ratios determined experimentally for other acids and with theoretical calculations of the ratios. A.

541.127.1

7343. Fractionation of the carbon isotopes in decarboxylation reactions. IV. The relative rates of decomposition of 1-C^{12} and 1-C^{13} trichloracetate ions. J. BIGELEISEN AND T. L. ALLEN. *J. Chem. Phys.*, **19**, 760–4 (*June*, 1951).

A precise determination of the relative rates of decomposition of 1-C^{12} and 1-C^{13} trichloracetate ions has been made. The 1-C^{12} ion has been found to decompose 1·0338 ± 0·0007 times as fast as the 1-C^{13} ion into chloroform and bicarbonate at 70·4°c. Trichloracetate ion has been found to undergo a decomposition reaction which gives chloride ion but no CO_2, OH^-, nor H^+. The ratio of the rate constants for the production of Cl^- and bicarbonate is 0·078. The errors in the determination of the effect of isotopic substitution on the rates of chemical reactions are discussed. In the study of the isotopes of carbon, experiments using mass spectrometric analyses of C^{13} at the natural abundance level are capable of a precision of one order of magnitude better than ones in which the specific activity of C^{14} is determined by counting. A.

541.128

7344. The reaction of methane and deuterium on evaporated nickel catalysts. C. KEMBALL. *Proc. Roy. Soc. A*, **207**, 539–53 (*July* 23, 1951).

The production of all 4 deuteromethanes from the reaction of methane and D on evaporated Ni films in the temperature range 206 to 255°c was followed by means of a mass spectrometer. The compound CD_4 was the most abundant product in the initial reaction, and there was other evidence that the adsorption of D was stronger than the adsorption of methane. The surface areas of the films were found by the adsorption of D at 0°c which was instantaneous and the films were shown by electron diffraction to be unorientated. An activation energy of about 11 kcal/mole was required for the adsorption of methane. Two types of reaction were distinguished: the first produced CH^3D with an energy of activation of 24 kcal/mole and the initial rate varied as $P_{CH_4}P_{D_2}^{-\frac{1}{2}}$; the second having an energy of activation of 32 kcal/mole, a greater entropy of activation and a rate dependent on $P_{CH_4}P_{D_2}^{-1}$, gave the other 3 compounds CH_2D_2, CHD_3 and CD_4. Mechanisms are formulated. The equilibrium constants for the interconversion of the 5 methanes were determined at 466°c and compared with calculated values. A.

ELECTROCHEMISTRY 541.13

541.133

7345. Transference numbers for sodium and potassium chlorides in anhydrous methanol at 25°c. J. A. DAVIES, R. L. KAY AND A. R. GORDON. *J. Chem. Phys.*, **19**, 749–51 (*June*, 1951).

Transference numbers have been determined by the moving boundary method for NaCl at concentrations from 0·003 to 0·01N, and for KCl at concentrations from 0·005 to 0·02N. Autogenic cells were used for cation boundaries and sheared cells (with paratoluene-sulphonate, di- and triiodobenzoate as indicator ions) for anion boundaries. The results are comparable in precision with those for aqueous solutions and satisfy all criteria for transference data.

The Longsworth function is linear in the concentration up to 0·01N, thus making it possible for the first time to obtain precise limiting transference numbers in an anhydrous solvent. A.

541.133

7346. Equivalent and ionic conductances for sodium and potassium chlorides in anhydrous methanol at 25°c. J. P. Butler, H. I. Schiff and A. R. Gordon. *J. Chem. Phys.*, **19**, 752–4 (*June*, 1951).

The conductance of NaCl and KCl has been determined in anhydrous methanol for concentrations from 0·0002 to 0·01N. For trace amounts of water, the decrease in equivalent conductance for a given electrolyte concentration is proportional to the water content, the proportionality factor being a function of the ionic strength. The results up to 0·002N satisfy the Onsager–Shedlovsky equation. The limiting conductances, when combined with the transference data (preceding Abstr.), give the first precise limiting ionic conductances in an anhydrous solvent. The limiting values for chloride ion are the same for the two salts within experimental precision; but with increasing concentration, there are deviations from the Kohlrausch rule of independent ionic mobilities which are considerably greater than is the case in aqueous solution. The equivalent conductance data are in definite disagreement with Frazer and Hartley's results for the two salts in this solvent. A.

541.133.1

7347. Electromigration in a cation exchange resin. K. S. Spiegler and C. D. Coryell. *Science*, **113**, 546–7 (*May* 11, 1951).

Movement of ions in a resin column has been followed by radiotracer technique, the adsorbed cations carrying the current. The resin phase is found to be the equivalent of an ionized salt solution, and in electrolysis where the slower follow the faster ions, sharp boundaries are obtained, e.g. in the system $Pt|NaR|ZnR_2|Zn$, the displacement of the boundary is proportional to the electric charge passed. 8 refs. H. H. Hodgson

541.135

7348. The solution of some potential problems in the theory of electrolytes. F. Booth. *J. Chem. Phys.*, **19**, 821–6 (*July*, 1951).

The Poisson–Boltzmann equation for the potential in an electrolyte is solved for the following cases: (*a*) electrolyte bordered by a uniformly charged plane; (*b*) two semi-infinite electrolytes of different composition separated by a plane boundary; (*c*) electrolyte confined between parallel charged planes; (*d*) uniformly charged cylinder immersed in an electrolyte; (*e*) electrolyte in a cylinder with charged walls; (*f*) electrolyte between two concentric charged cylinders; (*g*) solid charged sphere in an electrolyte; and (*h*) sphere of electrolyte immersed in another electrolyte extending to infinity, and of different composition. All the problems discussed are of interest in the theory of colloids or emulsions. In each case a series solution in powers of a parameter involving the charge or charges on relevant surfaces is given. The first term of each series is the solution of the Poisson–Boltzmann equation when the so-called Debye–Hückel approximation is applied to the equation. The additional terms are built up from the first by an iterative method. No restrictions on the compositions of the electrolytes are required. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14 : 542.944

7349. Bromination of hydrocarbons. IV. Photochemical and thermal bromination of neopentane in the gas phase. The C–H bond strength in neopentane. E. I. Hormats and E. R. Van Artsdalen. *J. Chem. Phys.*, **19**, 778–83 (*June*, 1951).

The homogeneous photochemical bromination of neopentane was studied in the temperature range 98 to 152°c and found to proceed through an atom and radical chain mechanism analogous to the bromination of methane and ethane. Hydrogen bromide inhibits photobromination of neopentane much more than it does in the case of methane, increasing in its effect with rising temperature. Thermal bromination was studied at 197°c and found to take place by a mechanism analogous to the photochemical reaction, the bromine atoms being produced thermally rather than photochemically. The corrected activation energy of the overall reaction was determined from the temperature coefficient of the photochemical reaction and found to be 17·8 kcal/mole. Questions of the efficiencies of various molecules as third bodies in the homogeneous recombination of bromine atoms and problems relating to steric effects in atom and radical reactions have been discussed. The C–H bond strength in neopentane has been estimated to be 95·5 kcal/mole at room temperature. A.

541.14 : 551.578

7350. Photolytic inactivation of ice-forming silver iodide nuclei. E. C. Y. Inn. *Bull. Amer. Met. Soc.*, **32**, 132–5 (*April*, 1951).

Photolytic decomposition of AgI crystals has been observed when the crystals were exposed to light of wavelengths less than 4 300 Å, as indicated by darkening of the exposed crystals. Qualitative observations indicate exposed AgI crystals undergo reversible photolysis, although the exact conditions under which this takes place is not well understood. When AgI nuclei were similarly exposed to light, the ability to form ice particles, when injected into a cloud of super-cooled water droplets, was found to be essentially destroyed. It is believed that, as a result of photolysis of the exposed AgI nuclei, the physicochemical nature of surface of the nuclei has been altered to minimize effectively the surface-structure sensitive process of ice nucleation. A.

541.15

7351. Free radicals produced by ionizing radiations in an aqueous medium. J. Weiss. *J. Chim. Phys.*, **48**, 233–6 (*May–June*, 1951).

Summary of experimental papers published by author and co-workers since 1947 (13 papers).

F. LACHMAN.

541.15

7352. The analogy between the chemical action of ionizing radiation and that of ultrasonics on aqueous solutions. N. MILLER. *J. Chim. Phys.*, **48**, 242–4 (*May–June*, 1951).

It has been found that the oxidation by ultrasonics of solutions containing more than $5 \cdot 10^{-4}$MFe^{++} in air-saturated 1N–H_2SO_4 was linear with time within the first few minutes of irradiation. A plot of the initial yield against the initial Fe^{++} concentration appeared to be quite analogous to similar plots obtained using ionizing radiation. From comparison with other results it is implied that the distribution of active radicals produced by ultrasonic radiation resembles that produced by γ-rays more closely than that produced by α-rays. Threefold increase of the sound intensity, or saturating with O instead of with air, failed to cause any measurable change in the yield. F. LACHMAN

541.15 : 539.16.08

Chemical dosimetry of ionizing radiations. See Abstr. 7200.

DISPERSIONS . COLLOIDS. ADSORPTION 541.18

541.18 : 535.43

7353. Light-scattering investigations of carefully filtered sodium silicate solutions. R. V. NAUMAN AND P. DEBYE. *J. Phys. Coll. Chem.*, **55**, 1–9 (*Jan.*, 1951).

The investigations were carried out with solutions of $SiO_2 : Na_2O$ ratios between 0·5 : 1 and 3·75 : 1 having mol.wts. between 60 and 400. No evidence of aggregation was found for ratios of 2·0 : 1 or lower. With higher ratios turbidities increase with concentration and are much greater than those of concentrated sucrose solutions. Thus there may be a small amount of aggregation but very large particles are not apparent. With the ratio of 3·75 : 1 turbidities and *p*H's increase with time and mol.wts. of 5000 to 10 000 are found. Viscosities are low in dilute solutions but increase rapidly with higher concentration. Comparisons of turbidity and viscosity are also made with polystyrene in various concentrations. R. NEUMANN

541.183 : 539.16

7354. Research on thin adsorbed layers by means of radioactive tracer elements. R. BERNARD, F. DAVOINE AND J. HIRTZ. *C.R. Acad. Sci., Paris*, **232**, 1826–8 (*May* 16, 1951) *In French.*

Glass disks in contact with vapour of tricresyl phosphate (P^{32}) have been found to have an adsorbed layer of this substance, the thickness of which was *c.* 10 Å when the adsorption took place at room temperatures, and *c.* 50 Å when the temperature was 220°C. F. LACHMAN

541.183.5

7355. Adsorption of water vapour on solid surfaces. W. H. J. VERNON; J. M. MACAULAY; F. P. BOWDEN AND W. R. THROSSELL. Letters in *Nature, Lond.*, **167**, 1037–8 (*June* 23, 1951).

Bowden and Throssell's conclusion [Abstr. 6542 (1951)] against the view that metal surfaces invariably adsorb water vapour strongly from air at high relative humidities, is now modified by Vernon to the case that adsorption is negligible if surface and atmosphere are both free from contamination, e.g. polished and degreased Ni surfaces submitted first to (*a*) pure air saturated with water vapour, and then to (*b*) purified and dried air to which a trace of SO_2 has been added, exhibit no change, whereas when the order is (*b*) and (*a*), the surfaces become covered with a visible film. Supporting experimental evidence is afforded by J. M. Macaulay, and by Bowden and Throssell. There are 6 references. H. H. HODGSON

CHEMICAL STRUCTURE 541.4/.6

541.41

7356. Production of pure selenium trioxide. H. A. LEHMANN AND G. KRÜGER. Letter in *Naturwissenschaften*, **38** (*No.* 9) 208 (1951) *In German.*

A chemical method is outlined which permits of producing any quantity of pure SeO_3. The method is represented by $K_2SeO_4 + nSO_3 \rightarrow K_2S_nO_{3n+1} + SeO_3$. W. SUMMER

541.42

7357. The pyrolysis of *iso*-propyl bromide. A. MACCOL AND P. T. THOMAS. Letter in *J. Chem. Phys.*, **19**, 977 (*July*, 1951).

541.45

7358. Acidity and the systems of acids and bases. R. DE CARVALHO FERREIRA. Letter in *J. Chem. Phys.*, **19**, 794 (*June*, 1951).

541.57

7359. A discussion on bond energies and bond lengths. Introduction. M. G. EVANS. *Proc. Roy. Soc. A*, **207**, 1–5 (*June* 7, 1951).

Introductory lecture defining the scope of discussion and describing the present achievements in the field of bond energies, bond dissociation energies, and ionic homopolar resonance. F. LACHMAN

541.62

7360. Unimerism. J. K. SENIOR. *J. Chem. Phys.*, **19**, 865–73 (*July*, 1951).

It is pointed out that, in the development of structural organic chemistry, those compounds which have no structural isomers play a crucial role. Since no general name has ever been given to compounds which meet this condition, they are here called "unimers." It is further shown that the molecular formula for a unimer must necessarily fulfil certain mathematical conditions. These conditions are set forth in 9 theorems. Some of these theorems are almost self-evident; for others, the proofs, although simple in plan, are exceedingly intricate in application. Consequently, the reader is referred for all proofs to a purely mathematical paper which will be published in the *American Journal of Mathematics*. Finally, a complete list of unimeric types is given. A.

541.62 : 535.343

7361. Substituted stilbenes. I. Absorption spectra. M. CALVIN AND H. W. ALTER. *J. Chem. Phys.*, **19**, 765–7 (*June*, 1951).

The absorption spectra of five pairs of *cis-trans*

isomers of substituted stilbenes have been measured. The spectra of the geometrical isomers of *p*-amino *p'*-nitro stilbene hydrochloride are compared with those obtained by previous work. A.

541.62 : 541.127

7362. Substituted stilbenes. II. Thermal isomerization. M. CALVIN AND H. W. ALTER. *J. Chem. Phys.* **19,** 768–70 (*June*, 1951).

The dependence of the rate of *cis-trans* isomerization on temperature has been determined for four para-substituted stilbenes. The rate parameters obtained are discussed relative to the theory of absolute reaction rates.

541.632

7363. Rotational isomerism in 2-methyl butane and 2 : 3-dimethyl butane. J. K. BROWN AND N. SHEPPARD. Letter in *J. Chem. Phys.*, **19,** 976–7 (*July*, 1951).

541.66

7364. Energy difference between the two rotational isomers of propylene dichloride. Y. MORINO, I. MIYAGAWA AND T. HAGA. Letter in *J. Chem. Phys.*, **19,** 791–2 (*June*, 1951).

The energy difference between the 2 isomers is *c.* 950–1050 kcal/mole, which is less than in the case of ethylene dichloride (1200 kcal/mole), apparently due to the effect of the CH_3-group. F. LACHMAN

CHEMICAL ANALYSIS 543/545

545.37

7365. Dropping amalgam electrodes. R. C. TURNER AND C. A. WINKLER. *Canad. J. Chem.*, **29,** 469–77 (*June*, 1951).

The anodic limiting current at a Pb amalgam dropping electrode is shown to be proportional to the concentration of the Pb in the amalgam, at constant flow rate. The original Ilkovic equation does not apply to the anodic limiting current from dropping amalgam electrodes. The anodic limiting currents with Pb and Cd amalgams have been found to agree with the 2nd approximation of the Ilkovic equation, as derived by Strehlow and Stackelberg for this process, for flow rates in the region below approximately 1·2 mgm per sec. With flow rates greater than this, the Pb amalgams gave a linear relation between the anodic limiting current divided by concentration and the mass flow rate. With Cd amalgams no such linear relation was evident and the magnitude of the limiting current depended on the size of the drops as well as on the mass flow rates. The half-wave potentials of Pb and Cd were found to depend on the flow rate of the dropping electrode. A.

545.822

7366. Spark analysis of semi-microsamples. W. J. WARK. *J. Opt. Soc. Amer.*, **41,** 465–7 (*July*, 1951).

A new method of mounting semi-microsamples for spectrographic analysis is described. The method is very flexible and is particularly adapted to those procedures involving limited samples. An appreciable decrease in the cost of high-purity spectrographic materials can be obtained. The method can be applied to arc or spark techniques without modification. A.

545.824

7367. Activation analysis with the Oak Ridge reactor. G. W. LEDDICOTTE AND S. A. REYNOLDS. *Nucleonics*, **8,** 62–5, 78 (*March*, 1951).

A brief outline of the method of chemical analysis by observation of the activities produced in a sample through (n, γ) reactions in a high thermal neutron flux. A table of the principal activities produced in most of the elements 1–83 with their thermal neutron activation cross-sections is included. L. R. SHEPHERD

545.827

7368. Parent peak intensities as a basis for estimating purities of deuterium substituted compounds. H. W. ROLLMANN AND H. L. MCMURRY. Letter in *J. Chem. Phys.*, **19,** 804 (*June*, 1951).

Mass spectrometer results on propane derivatives are presented to support the assumption that, when measured under the same conditions, parent peaks of compounds are almost unchanged by deuterium substitution. T. G. PICKAVANCE

CRYSTALLOGRAPHY 548

548.0 : 535.52

7369. Optical anisotropy of cubic crystals under quadrupole radiation. K. H. HELLWEGE. *Z. Phys.*, **129** (*No.* 6) 626–41 (1951). See also Letter in *Naturwissenschaften*, **38** (*No.* 6) 142 (1951) *In German.*

Cubic crystals behave isotropically towards electric and magnetic dipole radiation, but anisotropically towards quadrupole radiation. The intensity and polarization of quadrupole radiation exhibit a 7-fold optical symmetry corresponding to the 3 tetrad and 4 triad axes. H. A. Lorentz [*Proc. Acad. Amsterdam*, **24,** 333 (1921)] showed that the refractive index of cubic crystals has a similar 7-fold symmetry, and it is concluded that Lorentz's approximation corresponds to a consideration of quadrupole radiation. Classical crystal optics only takes dipole radiation into account. J. A. FRANKS

548.0 : 539.11

7370. Additive colouring of MgO crystals. H. WEBER. Letter in *Naturwissenschaften*, **38** (*No.* 6) 140–1 (1951) *In German.*

It is shown that the addition of O_2 to MgO produces two colour bands in the same positions (220 mu and 290 mu) as those previously observed after X-ray irradiation. The absorption coefficient of each band is proportional to the concentration of O atoms. J. R. MADDOX

548.0 : 539.32

7371. Zero temperature coefficient quartz crystals for very high temperatures. W. P. MASON. *Bell Syst. Tech. J.*, 366–80 (*April*, 1951).

To determine the angles of cuts for low temperature-coefficient crystals, the elastic constants of quartz

have been evaluated in the temperature range from −100°C to +200°C. This has been done by measuring a series of rotated Y-cut crystals in the thickness shear mode and a series of rotated X-cuts in the longitudinal length mode. From the measurements, low temperature-coefficients AT-, BT-, CT- and DT-type crystals can be determined which have their temperature of zero temperature-coefficient at any prescribed temperature. Calculations are given for the properties of crystals to operate at 200°C. The characteristics of an AT-type crystal have been investigated experimentally, and the measured results are in reasonable agreement with the calculations. It is shown that there is a maximum temperature of 190°C for which an AT-type crystal can have a zero temperature coefficient. A.

548.2

7372. The symmetry of carborundum crystals on the basis of vicinal phenomena. G. KALB AND W. WITTBORG. *Naturwissenschaften*, **38** (*No.* 7) 156–7 (1951) *In German.*

Type II SiC crystals show vicinal faces, forming an hexagonal spiral with rounded corners on (0001) faces, and an unsymmetrical four-sided pyramid on $(10\bar{1}0)$ faces. The crystal thus lacks vertical symmetry planes, and belongs to the crystal class 6. Type I crystals show a triangular spiral with remarkably sharp corners on (0001) faces, and thus belong to the crystal class 3. [The spirals bear a close resemblance to those interpreted as evidence for the screw-dislocation theory of crystal growth.] A. J. C. WILSON

548.24

7373. Twinning in bismuth. I. A. GINDIN AND V. I. STARTSEV. *J. Exp. Theor. Phys., USSR*, **20**, 738–41 (*Aug.*, 1950) *In Russian.*

The processes of twinning in Bi metal, calcite and $NaNO_3$ are compared. In Bi distortion of a single crystal rod on extension takes place by twinning and not, except quite close to the melting point, by gliding. As in calcite and $NaNO_3$ there are two limits of flow. At 140–150 g/mm² twin layers begin to thicken and at 215–225 g/mm² new layers form. Twinning produced by pressure from a knife blade was investigated. Two types of twins were produced. Sometimes planes with parallel faces extending to the opposite side of the rod appeared, but the usual type were wedge-shaped and did not reach the further side. The first type were produced only in specimens < 1 mm thick. Elastic twinning was not found. On annealing just below the melting point long wedged-shaped twins decreased slowly in length but not thickness. If $\geqslant 0{\cdot}05$ mm in thickness they remained and if $\leqslant 0{\cdot}002$ mm they disappeared gradually. This behaviour is not the same as the disappearance of twins in Fe crystals where twins vanish simultaneously in many places. A. L. MACKAY

548.5

7374. Spiral growth on carborundum crystal faces. A. R. VERMA; S. AMELINCKX. Letters in *Nature, Lond.*, **167**, 939–40 (*June* 9, 1951).

Growth spirals were observed on rhombohedral and hexagonal carborundum crystals. The spiral steps were found to be one unit cell high. S. Amelinckx made similar observations and concludes that Frank's theory of screw dislocations [Abstr. 1343 (1950)] conceived for growth from the vapour phase, also applies to growth from the melt. J. A. FRANKS

548.5

7375. Growth of large quartz crystals. C. S. BROWN, R. C. KELL, L. A. THOMAS, N. WOOSTER AND W. A. WOOSTER. Letter in *Nature, Lond.*, **167**, 940–1 (*June* 9, 1951).

Good quality quartz crystals weighing 15 gm were grown on (0001) seed plates in a steel autoclave by the temperature gradient method. The rate of deposition on each (0001) face was max. 0·5 mm/day, duration of growth 2–4 weeks. J. A. FRANKS

548.5 : 548.24

7376. A mechanism for the growth of deformation twins in crystals. A. H. COTTRELL AND B. A. BILBY. *Phil. Mag.*, **42**, 573–81 (*June*, 1951).

The principal difficulty in developing a dislocation theory of mechanical twinning has been to explain how a twin grows through a finite thickness of crystal. By extending the recent theory of slip bands, proposed by Frank and Read, it is possible to show that a dislocation can move steadily from plane to plane in a crystal. A theory of mechanical twinning, which is formally analogous to Frank's theory of crystal growth, can then be developed. The theory is applied to the body-centred and face-centred cubic lattices. A.

548.522

7377. Growth and manipulation of barium oxide crystals. R. L. SPROULL, W. C. DASH, W. W. TYLER AND A. R. MOORE. *Rev. Sci. Instrum.*, **22**, 410–14 (*June*, 1951).

A method is described for growing crystals of BaO from the vapour. Seeds of BaO crystals or "pseudo-seeds" of MgO crystals are placed in an enclosure of BaO in a vacuum furnace and heated at 1 400°C. Single BaO crystals as large as $1 \times 10 \times 10$ mm have been grown by this method. Since BaO decomposes very rapidly in the ordinary atmosphere, special techniques for manipulating the crystals are described. These techniques are useful in experiments on the optical, electrical and electronic properties of BaO. A.

548.538

7378. On oriented growth of crystals of organic compounds. J. WILLEMS. Letter in *Naturwissenschaften*, **38** (*No.* 9) 211–12 (1951) *In German.*

The transportation of organic substances through a surface adsorption layer of the substrate to form oriented crystals takes place at low temperatures. Oriented growth of pentachlorphenol on NaCl, orthoclase and cyanite occurs within 1–10 min at 65°C. Powdered pentachlorphenol on a cleavage plane of NaCl maintained at 4°C, exhibited oriented growth after eight days. J. A. FRANKS

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

7379. The frequencies and the anharmonicities of the normal modes of oscillation of alkali halide crystals. I. Lattice oscillations. K. S. KRISHNAN AND S. K. ROY. *Proc. Roy. Soc. A*, **207**, 447–60 (*July* 23, 1951).

These are calculated on the basis of the Born

model. If r be the small relative displacement of the two lattices, and lmn the direction cosines of r with reference to the cubic axes of the crystal, it is found that the potential energy can be expressed in the form $U = U_0 + ar^2 + br^4 + cr^4(l^4 + m^4 + n^4) + \ldots$, in which the constants U_0, a, b and c are readily evaluated. The coefficient of r^2 determines the frequency, and of r^4 the anharmonicity, of the lattice oscillation. This oscillation is characterized by the development of a homogeneous electric polarization in the medium. It is found that the polarization field acting on an ion tending to displace the ion has just the Lorentz value, whereas the field tending to polarize the ion is almost nothing. The anharmonicity of the lattice oscillation, unlike its frequency, is found to vary with the direction of the oscillation, from a large positive value along [111]: to a small negative value along [100]. Its effect on the frequency of the octave, and on the specific heat at constant volume, are discussed. A.

548.7

7380. Dissociation energies of the Cd^{++} vacancy complex and of the double vacancy in sodium chloride. J. R. Reitz and J. L. Gammel. *J. Chem. Phys.*, **19**, 894–9 (*July*, 1951).

Dissociation energies for two types of lattice imperfection (namely, the impurity ion vacancy complex and the double vacancy) have been determined theoretically for NaCl, using the semiclassical model of ionic crystals developed by Born and Mayer. The procedure followed in calculating these energies was based on the method developed by Mott and Littleton for computing the formation energies of single vacancies. The numerical results which were obtained are 0·44 eV and 0·89 eV for the dissociation energies of the complex and double vacancy, respectively. A.

548.7 : 535.343.2

7381. Color centers in additively colored alkali halide crystals containing alkaline earth ions. F. Seitz. *Phys. Rev.*, **83**, 134–40 (*July* 1, 1951).

The measurements of Pick on the absorption bands produced in additively coloured crystals of KCl and NaCl containing additions of divalent ions are reviewed and an interpretation of the origin of these bands is presented. Specific models are given for the Z_1, Z_2 and Z_3 centres responsible for the absorption bands observed by Pick. These resemble models proposed by Pick, but differ in several essential points. It is concluded that the divalent ions remain atomically dispersed in KCl when the crystal is quenched to room temperature from elevated temperatures, whereas some of the divalent ions and their associated positive-ion vacancies migrate to F-centres during the quenching process in NaCl. The observations also suggest that the divalent ions are not very mobile in KCl until a temperature near 200°C is attained, although the pair consisting of a positive and a negative ion vacancy becomes significantly mobile in the vicinity of 100°C. A number of experiments are proposed which may provide a more stringent test of the models suggested. A.

548.7 : 535.343.2

Note on the absorption spectra of pure and colored alkali halide crystals. *See Abstr.* 6856

548.7 : 539.152.2 : 535.343–14

7382. Nuclear resonance in crystals. E. M. Purcell. *Physica*, **17**, 282–302 (*March–April*, 1951).

Experiments on a number of crystals, including the ammonium halides, are described, and the relation of these studies to line-shape investigations is discussed. The coupling of a nuclear electric quadrupole to a vibrating lattice can be much stronger than the dipole effect. Pound has found examples in which this effect is dominant at room temperature, and has identified the mechanism as quadrupole coupling by selectively saturating one line of a quadrupole multiplet while observing the intensity of another. The relaxation time is not far from that predicted by Waller's theory, adapted to this case. The availability of crystals with a long relaxation time at room temperature has led to studies of the persistence of nuclear polarization when the crystal is removed from the magnet—in effect, "adiabatic demagnetization" from room temperature. It is possible to reverse the field in the crystal quickly, without reversing the polarization; the spin temperature is then negative, and the crystal emits, rather than absorbing, at resonance. A.

548.7 : 539.21

7383. Theory of the crystalline state. A. A. Vlasov and V. A. Yakovlev. *J. Exp. Theor. Phys., USSR*, **20**, 1109–15 (*Dec.*, 1950) *In Russian.*

As shown before [Abstr. 461 (1949)] the nature of the crystalline state may be represented in terms of a single distribution function, describing the condition of a single particle chosen at random from a group of identical particles. The expression obtained represents the criterion of crystallization, relating interaction forces, temperature and density of the medium. These results are now supplemented by the demonstration that the solution mentioned, periodical in space, is only one of the exact solutions of the fundamental equation of the problem (thus a non-uniqueness theorem), and further by the convergence investigation of the series of successive approximations not given before. The periodic solution obtained has certainly a direct bearing on the description of the process of formation of a crystal from a homogeneous phase, at least for substances with molecules of the type of the inert gases, i.e. with a radial law of the interaction forces.

B. F. KRAUS

548.7 : 539.389

7384. The production and detection of a non-equilibrium number of vacancies in a metal. A. S. Nowick. Letter in *Phys. Rev.*, **82**, 551 (*May* 15, 1951).

The excessive non-equilibrium number of vacancies is produced by quenching to room temperature a Ag–Zn alloy wire, previously held at 400°C, and detected by measurements of the anelasticity of the wire associated with the diffusion controlled preferential reorientation of solute atom pairs [see Abstr. 1356 (1947)]. A. D. LE CLAIRE

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 7308–12

548.73 : 535.42

7385. Optical methods in crystal-structure determination. C. A. TAYLOR AND H. LIPSON. Letter in *Nature, Lond.*, **167**, 809–10 (*May* 19, 1951).

A development of Bragg's "X-ray microscope" [*Nature, Lond.*, **143**, 678 (1939)] is described. As an illustration of its use, the orientation of the phthalocyanine molecule in its unit cell is determined.

A. R. STOKES

548.733

7386. An improved direct-reading X-ray microdensitometer. A. TAYLOR. *J. Sci. Instrum.*, **28**, 200–5 (*July*, 1951).

An improved microdensitometer suitable for use with X-ray diffraction patterns has been constructed. It is manually operated and employs the Dobson split beam principle whereby density readings are obtained directly from the position of a linear neutral grey wedge. The Se barrier-layer cell is connected to a galvanometer feedback system of rapid response. The comfort of the operator is considerably improved by mounting the handwheels which actuate the film and wedge on the left of the instrument and the galvanometer scale on the front. A.

548.734

7387. A method of microcrystal analysis. R. CASTAING AND A. GUINIER. *C.R. Acad. Sci., Paris*, **232**, 1948–50 (*May* 21, 1951) *In French.*

Kossel's method is applied to obtain a diffraction photograph, in a few minutes exposure time, of a very small region of a specimen; e.g. a photograph of a 10 μ dia. inclusion in an Al matrix proved that its structure was that of Al_2Cu and determined its orientation. A. R. STOKES

548.735

7388. Phase-limiting relations following from a known maximum value of the electron density. R. PEPINSKY AND C. H. MACGILLAVRY. Note in *Acta Cryst.*, **4**, 284 (*May*, 1951).

Such relations are probably less useful than those derived from the condition that the electron density must be positive [see Abstr. 6170 (1950)].

A. R. STOKES

548.735.44

7389. A multiple projector for the Huggins masks. D. MCLACHLAN, JR AND R. H. WOOLLEY. *Rev. Sci. Instrum.*, **22**, 423–7 (*June*, 1951).

The usual procedure for making two-dimensional Fourier projections of crystal structures by means of the Huggins masks requires the expenditure of time in the photographic darkroom during which errors may be made. These errors can be corrected only by a repetition of the entire laborious procedure of successive exposures of the plate. An apparatus is described whereby 144 Huggins masks are projected simultaneously on a screen and the result photographed. The projection is accomplished without lenses and the cost of production is thereby reduced considerably. Grooves are provided for changing the signs of the Fourier coefficients at will. Rheostats on the projection lamps are provided for controlling the lumination in proportion to the magnitude of the Fourier coefficients. A.

548.735.46

7390. Patterson transforms and the interpretation of X-ray scattering from fibers. G. H. VINEYARD. Note in *Acta Cryst.*, **4**, 281 (*May*, 1951).

A modification of the method of MacGillavry and Bruins [*Acta Cryst.*, **1**, 156 (1948)] for fibres with no periodicity in the direction of the fibre axis. C. TURNER

548.736.5

7391. X-ray study of the thermal decomposition of dolomite. H. G. F. WILSDORF AND R. A. W. HAUL. Letter in *Nature, Lond.*, **167**, 945–6 (*June* 9, 1951).

Single-crystal photographs show that $MgCa(CO_3)_2$ passes to $MgO + CaCO_3$ without change in lattice orientation. The mechanism of decomposition is discussed. A. R. STOKES

548.737

7392. The crystal structure of ribonuclease. I. C. H. CARLISLE AND H. SCOULOUDI. *Proc. Roy. Soc. A*, **207**, 496–526 (*July* 23,1951).

The unit cell dimensions of the crystals in the wet and air-dried states are as follows: wet crystal, $a = 30{\cdot}90$ Å, $b = 38{\cdot}80$ Å, $c = 54{\cdot}06$ Å, $\beta = 106{\cdot}0°$, $a \sin\beta = 29{\cdot}39$ Å; dry crystal $a = 29{\cdot}10$ Å, $b = 30{\cdot}08$ Å, $c = 51{\cdot}03$ Å, $\beta = 114{\cdot}0°$, $a \sin\beta = 26{\cdot}4$ Å. The densities of the wet and air-dried crystals were found to be 1·220 and 1·269 respectively, and the air-dried crystals contained 13·6% by weight of water. From the latter observations and the dry-cell dimensions, the molecular weight of ribonuclease, assuming 2 molecules in the unit cell, was calculated to be 13 400. This figure is in reasonable agreement with the determinations of molecular weight made by osmotic pressure and sedimentation-diffusion methods. The attempt has been made to interpret the Patterson vector projection maps in terms of sets of points chosen from the vector diagrams in such a manner that there is agreement between calculated and observed structure factors. This made it possible to construct a vector model of ribonuclease, which suggests that it contains 5 polypeptide chains, each with a minimum length of about 46 Å, lying parallel to one another on an hexagonal network and separated from each other by distances of about 9·5 Å. These preliminary investigations are insufficient to establish any connexions between the ends of the polypeptide chains, or of the nature of the intramolecular fold of the chains themselves. The dimensions of the molecule are approximately $18 \times 30 \times 48$ Å, and the evidence favours the existence of two amino-acids per 4·9 Å repeat unit along the axes of the polypeptide chains, assuming these chains to contain the α-type fold. The molecule contains something between 90 and 110 amino-acid residues. Independent confirmation of the direction of the polypeptide chains in the crystal has been provided from polarized i.r. absorption studies of the $-N-H-$ combination bands of the internal H bonds of the polypeptide chains. A.

548.74

7393. Dynamical theory of electron diffraction for a finite polyhedral crystal. I. Dynamical theory of electron diffraction for a finite polyhedral crystal. II. Comparison with the results of kinematical theory. N. KATO AND R. UYEDA. *Acta Cryst.*, **4**, 227–31 (*May*, 1951).

Bethe's theory is extended to cover the case of a

finite crystal of polyhedral shape in an attempt to understand the multiplet structure of Debye–Scherrer rings and the splitting of Laue spots, which are attributed to the refraction of the electron beam at the surface of micro-crystals. J. THEWLIS

548.74 : 539.185 : 535.42

7394. The structure of ammonium chloride by neutron diffraction. G. H. GOLDSCHMIDT AND D. G. HURST *Phys. Rev.*, **83**, 88–94 (*July* 1, 1951).

From the intensities of powder diffraction lines the positions of the deuterons in ND_4Cl have been deter mined at liquid N and room temperatures. Th experimental results confirm at low temperature th space group T_d^1 and the tetrahedral structure of th NH_4 ion with an N — D separation 1·03 Å. A room temperature the T_d^1 space group persists Neither free rotation nor disordered orientations c the NH_4 ions have been observed. Details concernin deuteron vibrations are discussed. A

GEOPHYSICS 55

550.341

7395. On the Zenneck ground wave. G. GOUBEAU. *Z. angew. Phys.*, **3** (*No.* 3–4) 103–7 (1951) *In German.*

A study is made of the field equations in cylindrical co-ordinates. It is shown that the ground wave may be realized physically and that the problem of exciting the wave is related to the excitation of an open wave conductor. Between the ground and space waves there exist orthogonality relations. These are studied and the amplitude of the ground wave is calculated in a simple case. L. S. GODDARD

550.342

7396. An investigation of the Uppsala microseisms. M. BÅTH. *Medd. Met. Inst. Uppsala, No.* 14, 168 *pp.* (1949).

Scandinavian records, particularly those recorded at Uppsala (Wiechert horizontal seismograph, 1 000 kg pendulum) over the period 1921–38 were analysed. It appears that the dominant role in the production of microseisms is played by the action of sea waves against the coast (principally the Norwegian) but a pressure effect ("barometric low" theory) could also be detected after eliminating the coast effect.

550.342

7397. The microseismic importance of cold fronts in Scandinavia. M. BÅTH. *Ark. Geofys.*, **1**, *Paper* 12 267–358 (1951).

See previous Abstr. Some possible causal relationships between cold fronts (or their passage over a coastline) and microseisms are investigated, partly theoretically and partly empirically. Eighteen particular situations from the years 1945–9 are investigated.

550.383 : 551.510.535

7398. Evidence for ionosphere currents from rocket experiments near the geomagnetic equator. E. MAPLE, W. A. BOWEN, JR., AND S. F. SINGER. Letter in *Phys. Rev.*, **82**, 957–8 (*June* 15, 1951).

Records of magnetic field as a function of altitude have been obtained with total field magnetometers off the west coast of Peru at a geomagnetic latitude of −1°. The results obtained confirm the existence of a current system in the *E*-region of the ionosphere. J. M. HOUGH

550.384.3

7399. The analysis of the geomagnetic secular variation. F. J. LOWES AND S. K. RUNCORN. *Philos. Trans A*, **243** (*No.* 871) 525–46 (1951).

After some discussion of the general properties of the secular variation field, a graphical method i described of analysing it in terms of separate dipole of arbitrary direction. The analysis shows that th major part of the field for epoch 1922.5 is explaine by about twelve vertical dipoles below the surfac of the core. The relation of this result with othe analyses by McNish (1940) and Bullard (1948) i discussed. The depth of the dipoles confirms tha the origin of the secular variation must lie in the cor of the earth; because of the high electrical con ductivity of the core material it must in fact be due t a thin current sheet at the surface of the core, and thi interpretation also gives an explanation for th existence of only vertical sources. The presence o only vertical sources, and in particular the presenc of several near the equator, does not support th existence of the toroidal field, which is an essentia step in Bullard's (1949) dynamo theory of the mai field. A

550.93 : 539.155.

7400. A modification of the isotopic method for th determination of geological ages. C. B. COLLINS J. R. FREEMAN AND J. T. WILSON. Letter in *Phys Rev.*, **82**, 966–7 (*June* 15, 1951).

Nier's method has been modified to use lea tetramethyl instead of lead iodide in order to simplif the use of the mass spectrometer. The modifie method has been applied to age determinations in th Canadian Shield. J. M. HOUG

551.311.123 : 539.37

7401. The flow of glaciers and ice-sheets as problem in plasticity. J. F. NYE. *Proc. Roy. Soc, A* **207**, 554–72 (*July* 23, 1951).

A calculation is made of the distribution of stres and velocity in an ideal glacier and in an ideal ice sheet. The ice is assumed to have a constant yiel stress and to obey, like other polycrystalline plasti aggregates, the Lévy–Mises equations of flow an either the Mises or the Tresca criterion of yielding The solution obtained for an ideal glacier represent the two-dimensional flow of a long slab of ice dow a gently undulating rough slope. The addition of ic to the upper surface by snowfall and the removal c ice by ablation are allowed for, but the friction resistance of the sides of the glacier valley is neglected Two states of flow are possible, "active" an "passive," corresponding to the active and passiv Rankine states in soil mechanics. The second solutio obtained is formally similar but represents the two

dimensional flow of a large ice-sheet, such as the Greenland ice-cap. A.

551.351 : 539.16.08

7402. Radium and deep-sea chronology. H. PETTERSSON. Letter in *Nature, Lond.*, **167**, 942 (*June* 9, 1951).

A method is described by which the rate of sedimentation on the sea bottom can be deduced from the amount of ionium in deep-sea cores. The radium carrying the ionium is measured. The importance of little disturbance to the uppermost layer of cores is emphasized. R. S. READ

ATMOSPHERE . METEOROLOGY 551.5

551.508.43 : 533.45

A new instrument for microbarometric investigations. *See Abstr.* 6782

551.508.5

7403. A portable recording pressure-plate anemometer. E. L. DEACON. *J. Sci. Instrum.*, **28**, 217–19 (*July*, 1951).

While sufficiently robust for field use, the instrument is responsive enough to record fluctuations in wind velocity up to a frequency of 1 or 2/sec. It is independent of all electric power supplies and has a stable calibration. A.

551.510.4

7404. A self-consistent treatment of the oxygen dissociation region in the upper atmosphere. H. E. MOSES AND T.-Y. WU. *Phys. Rev.*, **83**, 109–21 (*July* 1, 1951).

A self-consistent theory is suggested for the determination of the distribution of atomic and molecular O and the temperature in the region 100–140 km of the atmosphere. It is assumed that solar radiation is responsible for the photodissociation of the O molecules, and that the recombination of the atoms by two-body radiative processes is more important than that by three-body collisions (as justified from theoretical considerations). From the postulated conditions for the steady state, namely, for any given volume, (*a*) the average time rate of dissociations equals that of recombinations, and (*b*) the average time rate at which radiation energy is absorbed in dissociation processes equals that at which radiation energy is emitted in recombination processes, together with an appropriate form of the barometric equation, it is possible to obtain the concentrations of the molecular and the atomic O and the temperature, all as functions of height, provided the temperature and its gradient are given at one height. Calculations have been carried out for 3 sets of these boundary values at 100 km, namely, (i) $T = 300°\text{K}$, $dT/dx = 10°/\text{km}$, (ii) $T = 300°\text{K}$, $dT/dx = 5°/\text{km}$, and (iii) $T = 270°\text{K}$, $dT/dx = 5°/\text{km}$. In all these cases, dissociation begins between the heights 90 and 100 km and is not complete until around 150 km. The total gas pressure for various heights above 100 km calculated for case (iii) above agrees quite well with the data obtained from V-2 rocket flights. In the appendices, three-body recombinations are discussed. The cross-section for a three-body recombination process is defined, and its relation with the cross-section of its inverse two-body excitation process is obtained on statistical mechanical arguments. Also, the relation between the absorption coefficient for a photodissociation process and the cross-section of its inverse radiative recombination process is obtained. A.

551.510.41

7405. The abundance and vertical distribution of methane in the earth's atmosphere. L. GOLDBERG. *Astrophys. J.*, **113**, 567–82 (*May*, 1951).

Theoretical expressions are derived for the equivalent widths of CH_4 lines formed in the earth's atmosphere which take into account the variation of pressure and temperature with altitude in the atmosphere. When allowance is made for the curvature of the earth, information on the vertical distribution of CH_4 can be obtained from low-sun observations. The theoretical formulae have been employed for the analysis of observations of the 0–1, 5–6 and 10–11 lines in the $2\nu_3$ band of CH_4 at $1{\cdot}666\ \mu$ in the solar spectrum. From observations made at Lake Angelus, Michigan and Mount Wilson, California, the total number of CH_4 molecules per square centimetre through the zenith are found to be $3{\cdot}2\times10^{19}$ and $2{\cdot}6\times10^{19}$ respectively. The ratio of abundances is very nearly that which would be expected if the distribution of CH_4 is world-wide and falls off exponentially with height at the same rate as the main body of the atmosphere. The observations are well represented by theoretical curves of growth for pure damping, with $\gamma/4\pi = 1{\cdot}2\times10^9\ \text{sec}^{-1}$ for Lake Angelus and $\gamma/4\pi = 1{\cdot}0\times10^9\ \text{sec}^{-1}$ for Mount Wilson. Within the experimental error the ratio of damping constants is equal to the ratio of ground-level pressures at the two stations, in agreement with theory. A.

551.510.535

7406. On the variations in *F*2-layer height. R. EYFRIG. *Z. angew. Phys.*, **3** (*No.* 3–4) 96–103 (1951) *In German.*

Data from a number of stations on the variation of the *F*2-layer M.U.F. factor (M 3000) are considered in relation to sunspot numbers. It is found that the average noon values of M 3000 are symmetrical about the magnetic equator but the influence of geographical latitude seems to predominate in the night values. W. J. G. BEYNON

551.510.535

7407. Enhanced trans-equatorial propagation following geomagnetic storms. O. P. FERRELL. Letter in *Nature, Lond.*, **167**, 811–12 (*May* 19, 1951).

Report on successful radio amateur communication in Oct.–Nov., 1949, on frequency of 50 Mc/s between N. and S. America, during, or shortly after, moderately severe, or severe geomagnetic storms, indicating enhanced *F*2-layer ionization in equatorial regions at such times. W. J. G. BEYNON

551.510.535 : 538.566.3

Radio-wave propagation in the ionosphere. *See Abstr.* 7129–35

551.510.535 : 550.385

7408. Influence of magnetic storms on the *F*2-region. R. EYFRIG. *C.R. Acad. Sci., Paris*, **232**, 2125–7 (*June* 4, 1951) *In French.*

A statistical study of ionospheric storms during

1948–50 has shown a strong asymmetry in the ionization during the northern summer. The ionization is diminished in the southern hemisphere and increased in the northern. J. M. HOUGH

551.510.535 : 551.524.7

7409. A critical survey of ionospheric temperatures. N. C. GERSON. *Rep. Phys. Soc. Progr. Phys.*, **14**, 316–65 (1951).

Methods are discussed for finding the variation of temperature with (1) collision frequency, (2) auroral scale heights, (3) electron concentration, (4) influx function, (5) recombination coefficient. The probable temperature-altitude relationship in the region 100–400 km is tabulated. A.

551.510.535 : 621.396.11

7410. On the diurnal variation of the signal propagation and of the frequency between America and Europe. A. STOYKO AND N. STOYKO. *C.R. Acad. Sci., Paris*, **232**, 1817–18 (*May* 16, 1951) *In French.*

The transit time is $0{\cdot}7–0{\cdot}8\times10^{-3}$ less in the morning and in the evening than in the middle of the day. The frequency is about 6×10^{-8} higher in the morning than in the evening. An explanation is given based on the movement of the F_1-layer. L. PINCHERLE

551.511

7411. The thermal excitation of atmospheric oscillations. M. V. WILKES. *Proc. Roy. Soc. A*, **207**, 358–70 (*July* 6, 1951).

The excitation by thermal action of large-scale oscillations in an atmosphere on a rotating globe is discussed. The temperature of the atmosphere varies in an arbitrary manner with height. The treatment follows the same lines as that given by Pekeris for gravitationally excited oscillations, and the results are expressed in terms of an "equivalent gravitational oscillation." Some numerical results are given for the case of the solar semi-diurnal oscillation and are found not to conflict with the hypothesis, put forward by Chapman in 1924, that the thermal and gravitational contributions to this oscillation are of the same order of magnitude. A.

551.513

7412. Dynamic atmospheric equations in generalized coordinates. Application to the case of spherical coordinates. J. VAN MIEGHEM AND A. VANDENPLAS. *Inst. Roy. Met. Belge Mém., No.* 41, 26 *pp.* (1950) *In French.*

The method used is based essentially on any change of spatial variables, containing time explicitly, applied to the dynamical equation and the equation of continuity written in Cartesian co-ordinates in a Galilean system of reference. After recalling the ideas of speed, acceleration, divergence and rotation defined in any system of mobile co-ordinates the Eulerian form is first established and finally the rotational form of the equation of motion. As applications the classical equations in Cartesian and spherical co-ordinates fixed with reference to the earth are envisaged. Then the case of spherical co-ordinates with an axis coinciding with any diameter of the earth is considered. Finally the case is examined of a single circular vortex with vertical axis which moves under the influence of a horizontal Coriolis force. R. S. READ

551.513

7413. Atmospheric waves associated with discontinuities of a vortex (planetary and cyclonic waves). P. QUENEY. *C.R. Acad. Sci., Paris*, **232**, 1954–6 (*May* 21, 1951) *In French.*

The waves considered are adiabatic and non-divergent superposed on the general current at levels near 12 km, where the energy of this circulation is a maximum and where synoptic motion is of this nature. Expressions are obtained for systems consisting of two or more currents. These lead to the proposed theorem: under the action of strong convection having its seat in the lower atmosphere (warm sea with colder air) the jet stream can be slowly retarded in a zonal band fairly well defined and not too much extended along the axis. This introduces a negative value of vorticity sufficiently near to this axis for unstable waves of well-defined length to develop which would be cyclonic. The theory can be applied to extra-tropical and tropical cyclones. Cyclones would thus be due to interaction of thermal instability of the lower atmosphere (or eventually on the O_3 layer) and a dynamical instability in layers near 12 km. R. S. READ

551.513 : 551.576

7414. Theory of formation of descending currents of cumulo-nimbus. J. LACAZE. *Rev. Sci., Paris*, **88**, 195–201 (*Oct.-Dec.*, 1950) *In French.*

Observation and study of sand devils with vertical axes has led to the idea that these meteors apply a type of convection which exists, and probably frequently, in non-desert areas. The phenomena are described and compared with earlier models of atmospheric convective currents due to Bénard and Petterssen. The conditions of their formation, extension and progress are indicated and a general theory given and compared with that by Williams. Using an idea by Priestley it is shown that conditions near the surface relating to the characteristics of sand devils are found again at higher levels as soon as a horizontal layer of air presents strong heterogeneity particularly for content of water, the heat of condensation of the water playing a role similar to the heat enclosed in the sand whirl. Helicoidal whirls with quasi-vertical axes, forming at the level of cloud layers, are considered and their consequences studied first on the formation of waterspouts and tornadoes and finally on the structure of cumulo-nimbus clouds. R. S. READ

551.521.63 : 523.75

7415. Intensity of ultraviolet radiation from solar flares. R. N. SEDRA. Letter in *Phys. Rev.*, **83**, 190 (*July* 1, 1951).

Assuming the change of the terrestrial magnetic field which accompanies a solar flare to be dependent on the intensity of u.v. radiation emitted, calculations show that the u.v. intensity at an atmospheric level of 200 km, due to a major flare, is > the normal solar radiation at this height by a factor of 2 500. D. R. BARBER

551.573

7416. The role of vegetation in meteorology, soil mechanics and hydrology. H. L. PENMAN. *Brit. J. Appl. Phys.*, **2**, 145–51 (*June*, 1951).

Plant transpiration plays a dominant part in the

water and heat balances of the earth's surface, and affects land drainage, underground storage and river flow. Calculation of the transpiration rate can be made the basis of controlled irrigation to produce maximum growth without waste of water, and it is shown that the principle can be applied equally successfully to a field, to a catchment area and to the British Isles as a whole. When the plants grow in a clay soil, shrinkage may occur as the soil dries, with damaging results on roads or buildings carried on the soil. A.

551.576

7417. The microphysics of clouds. B. J. MASON AND F. H. LUDLAM. *Rep. Phys. Soc. Progr. Phys.*, **14,** 147–95 (1951).

Recent research is described and assessed. The mode of action, nature and possible origin of atmospheric condensation nuclei are discussed. The growth of populations of these nuclei, to form cloud and fog, is considered in relation to the properties, concentration and size distribution of the nuclei and the properties of the air mass. The opposing theories of cloud-droplet growth by diffusion and by coagulation are critically examined. An account is given of various techniques for determining drop-size distribution. The results of recent experiments on the supercooling and freezing of water and on the concentration and behaviour of ice-forming nuclei are examined. A new theory of the formation of ice crystals, snow flakes and hailstones is outlined. The possible mechanisms of rain formation receive special attention. The possibility of producing rain by artificial stimulation is briefly discussed. A.

551.578 : 541.14

Photolytic inactivation of ice-forming silver iodide nuclei. *See Abstr.* 7350

551.593.5

7418. The blue colour of the sun on September 27, 1950. P. WELLMANN. *Z. Astrophys.*, **28** (*No.* 3) 310–14 (1951) *In German.*

Spectrophotometric observations of the phenomenon in the photographic range yield evidence of the size, abundance and nature of the opaque particles causing the anomalous extinction. M. W. OVENDEN

551.593.7

7419. The brightness and polarization of the daylight sky at altitudes of 18 000 to 38 000 feet above sea level. D. M. PACKER AND C. LOCK. *J. Opt. Soc. Amer.*, **41,** 473–8 (*July*, 1951).

The brightness and polarization of the daylight sky over Arizona and Southern California were measured from B-29 aircraft while flying at altitudes of 18 000, 27 500, 34 000 and 38 000 ft above sea level. Comparison of the results with the Tousey and Hulburt theory of sky brightness showed that the theory agreed fairly well with the experimental data for all altitudes of observation, for all points in the sky more than 30° from the horizon, and for scattering angles greater than about 40° from the sun, when an atmospheric attenuation coefficient of 0·017/km was assumed. The values of sky brightness observed at scattering angles within 30° of the sun indicated that large scattering particles were present in the atmosphere overhead at all altitudes of observation including 38 000 ft. A.

551.593.9 : 551.594.5

7420. The spectrum of the airglow and the aurora. A. B. MEINEL. *Rep. Phys. Soc. Progr. Phys.*, **14,** 121–46 (1951).

The spectrum of the night-glow is investigated from 3 000 Å to 14 μ. O_2, N_2 and OH contribute emissions between 3 000 Å and 4·5 μ. The enhancement of the N_2^+ bands and the [O I] and Na *D*-lines during twilight is attributed to resonance scattering. The major features of the auroral spectrum are well identified, but there is still uncertainty as to the existence of ionized atomic emissions. Protons of extra-terrestrial origin are the primary particles of the aurora. Much progress has been made in height and temperature determinations for the airglow; but outstanding discrepancies still exist for the Na *D*-lines and for the Herzberg and Vegard–Kaplan bands. A.

551.594.21

7421. Magnetic-tape recording of electrostatic field changes. N. D. CLARENCE AND D. J. MALAN. Letter in *Proc. Phys. Soc., Lond. B,* **64,** 529 (*June* 1, 1951).

551.594.3

7422. Radio observations of the aurora on November 19, 1949. N. C. GERSON. *Nature, Lond.*, **167,** 804–5 (*May* 19, 1951).

Radio amateur observations in U.S.A. and Canada of abnormal propagation on 50 Mc/s are interpreted in terms of signals reflected from aurorae. In a particular case such observations are used to determine the existence and spatial extent of a polar aurora. Possible causes for the fading characteristics of the received signal are briefly discussed.

W. J. G. BEYNON

551.594.5

7423. Atomic nitrogen in auroras. S. K. MITRA. Letter in *Nature, Lond.*, **167,** 897 (*June* 2, 1951).

Two probable origins for the forbidden N emissions are suggested, involving (i) dissociative recombination of $N_2^+(X')$ ions; or (ii) neutralization of N_2^+ ions by electron transfer in the presence of negative ions of O. Both reactions are likely, and the probability of the first is the higher. D. R. BARBER

551.594.51

7424. The auroral spectrum from 6 200 to 8 900 A. A. B. MEINEL. *Astrophys. J.*, **113,** 583–8 (*May*, 1951).

The i.r. region of the auroral spectrum is rich in molecular and atomic emissions. The molecular bands are due to a new system of N_2^+, the first positive system of N_2, and the atmospheric system of O_2. Several permitted atomic lines of N I and O I, as well as Hα, are present. A table of wavelengths and intensities has been prepared. A.

551.594.6 : 538.566.2 : 621.396.11

7425. Fluctuations in the refractive index of the atmosphere at microwave frequencies. G. BIRNBAUM. Letter in *Phys. Rev.*, **82,** 110–11 (*April* 1, 1951).

Note on some preliminary measurements made with a recording microwave refractometer employing cavity resonators [see Abstr. 4948 (1950)]. Typical records of atmospheric refractive index fluctuations observed over a period of minutes and for various separation distances between two cavity resonators are shown. The application of the method in estimating the random refractive index inhomogeneities is noted. W. J. G. BEYNON

BIOLOGY 57/59

576.8.094.2

7426. On the size, shape, and hydration of southern bean mosaic virus and tobacco necrosis virus in solution. B. R. LEONARD, JR., J. W. ANDEREGG, P. KAESBERG, S. SHULMAN AND W. W. BEEMAN. Letter in *J. Chem. Phys.*, **19**, 793–4 (*June*, 1951).

Size measured by X-ray scattering. There is strong evidence for the sphericity of the viruses, radii 149 ± 3·3 and 150 ± 2·8 Å respectively. These give molecular volumes > those determined by other methods, the difference being attributed to hydration.

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.72 : 535.8

The geometrical and physiological magnification of optical instruments. *See Abstr.* 6908

612.842

7427. Studies of rod-process by polarization method. K. MOTOKAWA, M. EBE, Y. ARAKAWA AND T. OIKAWA. *J. Opt. Soc. Amer.*, **41**, 478–81 (*July*, 1951).

Based upon differences in velocity of changes in electrical sensitivity of the eye after exposure to a flash of light, it is possible to isolate a rod-process from a mixture of cone- and rod-processes. By means of this method rod-responses to spectral lights were measured at 20° from the fovea as a function of wavelengths. The spectral distribution of rod-responses determined in this manner is found in satisfactory agreement with the scotopic visibility curve. Rod-responses to a flash of weak white light were measured at various parts of the retina. The spatial distribution of rod-responses so obtained is found to show close resemblance to the density distribution of rods in the retina, although the maximum of the former is displaced farther in the periphery beyond the maximum of the density as the intensity of the flash is reduced. A.

612.843.2

7428. The decrease of critical flicker frequency with age. H. MISIAK. *Science*, **113**, 551–2 (*May* 11, 1951).

The critical flicker frequency (c.f.f.) is inversely proportional to age, dropping from 43 flashes per sec at 7 to 35 at 90 years, the luminance of the test-field (angular dia. 48′) not being specified. The errors are large, and the absence of an artificial pupil in the test apparatus is advanced as a possible explanation of the effect, since the progressive importance of the parasympathetic system with age would lead to a more pronounced pupil reflex, a reduced retinal illumination, and thus a lower c.f.f. R. A. WEALE

612.843.613

7429. Quanta and visual thresholds. M. H. PIRENNE AND E. J. DENTON. Letter in *J. Opt. Soc. Amer.*, **41**, 426–7 (*June*, 1951).

This critical review of van der Velden's and Bouman's work on quantum fluctuation contains a reply to their criticism of similar work carried out by Hecht, Shlaer and Pirenne. R. A. WEALE

612.8

7430. The problem of the brain mechanisms for th binaural functions of summation and lateral localizatio H. PIÉRON. *Ann. Télécommun.*, **6**, 102–9 (*April*, 195 *In French.*

The basis of the relation established by Fletche and Munson [*J. Acoust. Soc. Amer.*, **5**, 82–108 (1933 between stimulation intensity and loudness is criticall examined and the difficulties of reconciling it wit the nervous processes in binaural hearing ar considered. G. F. HODSMA

612.8

7431. The influence of interaural phase on maske thresholds. I. The role of interaural time-deviatio F. A. WEBSTER. *J. Acoust. Soc. Amer.*, **23**, 452–6 (*July*, 1951).

When a narrow band of noise, of constant leve (the signal) is masked by a wider band of noise (th masker), the amount of noise required to drown ou the signal often depends significantly upon the inte aural phase relations of signal and masker. Th out-of-phase signal shows an advantage in audibility An important property of physical stimuli tha produce an audibility-advantage is an interaura phase-deviation caused by the signal. When th signal is added to a corresponding masking com ponent, the combined pressure-wave, on the average leads in one ear and lags in the other. The resultin phase-deviation depends upon the relative levels an phase-positions of the masking and masked com ponents. It is maximum when these components ar 90° apart. The interaural time-deviation thus pro duced depends also upon frequency. If the frequenc is increased, the level of the masking component mus be decreased in order to hold the time-deviatio associated with the different frequencies, constan The present experiments showed that, with the ou of-phase signal, the decline in level of masking, as function of frequency, is just such as to hold th interaural time-deviation (for the 90° positio constant at about 125 μsec. Tonal signals tend t show a decreasing critical time-deviation wit increasing frequency. A

612.8

7432. Information and the human ear. H. JACOBSO *J. Acoust. Soc. Amer.*, **23**, 463–71 (*July*, 1951).

Calculations of the informational capacity of th human ear are made by computing the number c discriminable sound patterns per second, and applyin the Shannon information theory. A maximum c 10^4 bits/sec transmission is found. This is compare with the capacity of existing auditory channels an recording media, and with the rate of actual informa tion perception from speech and music. It is show that a capacity of upwards from 5×10^4 bits/sec depending on the informational match to the ear, i necessary for high fidelity transmission or recordin It is also shown that the brain can utilize less than 1% of the information transmitted by the ear. Finally an average capacity of about 0·3 bit/sec, or c

40 tones/sec, is calculated for an individual cochlear fibre. A.

614.898

7433. Recovery from radiation injury. L. O. JACOBSON, E. L. SIMMONS, E. K. MARKS AND J. H. ELDREDGE. *Science*, **113**, 510–11 (*May* 4, 1951).

It is shown that survival of mice, after whole body irradiation of 1 025 r from 250 kvp X-rays, increases when various organs have been Pb shielded. This is most marked for the haemopoietic tissues, notably the spleen. Splenectomy, from 1–6 hr after spleen-shielded irradiation, has little effect on survival. Transplantation of spleen into the peritoneal cavity of irradiated mice, increases the survival. It is suggested that irradiation produces a "toxin" and that the shielded or implanted tissues exert a detoxifying action. The efficacy of water extracts of spleen on survival and haemopoietic recovery are now being studied. D. V. MABBS

614.898

7434. A set of parts for the remote handling of radioactive substances. A. B. RITCHIE AND W. T. SPRAGG. *J. Sci. Instrum.*, **28**, 214–16 (*July*, 1951).

The set consists of tong rods, detachable tong jaws, a railway system for conveying jaws and reagents behind shielding and spherical ball joints. The set permits flexible manipulations using distance, Perspex or lead shielding. A.

615.849

7435. Radiocobalt (Co^{60}) as a therapeutic alternative to radium. C. W. WILSON. *Amer. J. Roentgenol. Radium Ther.*, **65**, 726–36 (*May*, 1951).

Co^{60} offers the possibility of γ-ray sources up to 2 000 c as well as needles and "tubes" of small diameter. The latter are best made of a Co–Ni alloy (Cobanic) for mechanical strength while strong sources need to be of high specific activity to minimize self-absorption. The loss due to this latter is about 50% in a 3-cm thick source. The absence of "dead ends" and of the need for sealing against radon leak in needles are advantages over radium. Protection of tele-curie sources is discussed and tables are given for the relative values of Pb, W alloy and U for Ra and Co^{60} sources. F. T. FARMER

615.849

7436. Measurement of skin dose in radium therapy. H. D. GRIFFITH AND G. E. SWINDELL. *Brit. J. Radiol.*, **24**, 337–40 (*June*, 1951).

The first method described uses a fluorescence meter. A small disk (8 mm dia.) cut from a radiological intensifying screen is mounted on a Perspex rod near a 931 Å photomultiplier tube. With a one-stage amplifier gamma-ray dose rates from 5–120 r/hr can be measured. The second method uses small G.M. counters, one such, having an effective counting volume 5 mm by 8 mm dia., being useful over the range 5 mr/hr to 10 r/hr. L. E. MUSSELL

616–073 : 539.16.08

7437. The use of positron-emitting radioisotopes for the localisation of brain tumours. F. R. WRENN, JR., M. L. GOOD AND P. HANDLER. *Science*, **113**, 525–7 (*May* 4, 1951).

The two γ-quanta resulting from positron annihilation with these radioisotopes emerge simultaneously and oppositely-directed. Hence, two coincidence counters could indicate that the source of activity must lie on a straight line joining them. Experimental results in localizing point sources of Cu^{64}, both in air and within a skull, are compared using (*a*) two crystals counting coincidences and (*b*) a single collimated crystal. Curves of counting rate plotted against position are much sharper when coincidences are counted as in case (*a*); since recorded coincidences are largely independent of scatter, lead collimation need not be used. D. V. MABBS

616–7 : 539.16.08

7438. Physical aspects of rotation therapy with the betatron. I. J. S. LAUGHLIN, R. A. HARVEY, L. L. HAAS, J. E. LINDSAY AND J. W. BEATTIE. *Amer. J. Roentgenol. Radium Ther.*, **65**, 947–51 (*June*, 1951)

A general mathematical expression is derived which permits the accurate calculation of resultant dose distributions produced in rotating irradiated bodies. This equation is applied to the particular case of cylindrical bodies for high-energy X-rays and for electrons (both from a 20 MeV betatron). Experimental and theoretical distributions in cylindrical phantoms are compared and, in the case of high-energy X-rays, where side scatter is small, agreement is good. These mathematical and experimental techniques form the basis of an investigation of dose-distribution in various regions of the human body. D. V. MABBS

TECHNICAL MATERIALS 66/67

669 : 548

7439. Progress in metal physics. II. B. CHALMERS (ED.). *London, Butterworth's Scientific Publications*; *New York, Interscience Publishers* (1950) 213 *pp.*

For Vol. I, see Abstr. 6922 (1950). In the second of the annual volumes the following papers are included, papers (5) to (7) constituting a symposium on polygonization: (1) *Order-disorder changes in alloys* (H. Lipson), to be regarded as complementary to the earlier review by Nix and Shockley; the more common superlattice structures are described and a brief theoretical outline is given; experimental investigations by X-ray diffraction, thermal, electrical, magnetic and mechanical measurements are described; (2) *Rate processes in physical metallurgy* (I. I. Betcherman), an application of the activation energy concept to the diffusion process in the main, but also to precipitation processes, flow of solid metals, stress-strain relations and recrystallization; (3) *Anisotropy in metals* (W. Boas and J. K. Mackenzie), giving a mathematical discussion (vectors, tensors) and treating mainly elastic, thermal and electrical aniso-

tropy; experimental data on bulk properties are fully tabulated and surface properties are discussed; (4) *Developments in magnesium alloys* (H. G. Warrington), dealing mainly with the structure and properties of commercial Mg base alloys with Al, Zr, Li and other metals; (5) *Internal strains and recrystallization* (R. W. Cahn), in which the relatively novel polygonization process is described, and the nature of the process in bent crystals discussed theoretically (see Vol. I, part 2); grain growth, primary and secondary recrystallization are also discussed; (6) *Researches on the polygonization of metals* (A. Guinier and J. Tennevin), describing results of a new experimental technique [*Acta Cryst.*, **1**, 188 (1948)] and their interpretation and comparison with earlier investigations; (7) *Polygonization in strongly deformed metals* (C. Crussard, F. Aubertin, B. Jaoul and G. Wyon), giving experimental evidence for the process occurring in heavily cold-worked metals, by micrographical, X-ray diffraction, thermoelectric and other investigations. The book contains some 100 figures and plates, several tables, extensive lists of references and subject and author indexes.

E. P. WOHLFARTH

669–492.

7440. A method for annealing metal powders without sintering. F. W. VON BATCHELDER AND H. E. STAUSS. *Rev. Sci. Instrum.*, **22**, 396–7 (*June*, 1951).

A method is described for maintaining the separation of the component particles during the annealing of a metallic powder. The technique consists of mixing the metal powder with a larger quantity of a second powder that is inactive chemically relative to the metal, annealing the mixed powders, and separating the metal by dissolving the inert powder after annealing. In this way Au, Ag and Fe powders have been annealed in NaCl without sintering. A.

PHOTOGRAPHY 77

771.53

7441. The theory of photographic processes. J. W. MITCHELL. *Bull. Soc. Roy. Sci. Liège*, **20**, 300–22 (*April*, 1951) *In French.*

A lecture on current theoretical ideas on the absorption of energy by silver halides, the electronic and atomic processes leading to the formation of the latent image, the mechanism of chemical sensitization, and the role of *F*-centres in the production of developable Ag specks. S. T. HENDERSON

778.3 : 621.3.012 : 621.317.755

7442. Problem of the speed of recording of a cathode ray oscillograph using an external camera. V. P. SHASHERIN. *J. Tech. Phys., USSR*, **21**, 92–103 (*Jan.*, 1951) *In Russian.*

Theoretical determination of the maximum recording speed with the use of an external camera, considering conditions of exposure, time bases (electrical or mechanical) inertia characteristics of screen, afterglow and characteristics of lens of camera and film material. A comprehensive analysis is given of previous work in this field by Western and Soviet authors. B. F. KRAU

778.3

7443. The photographic study of rapid events. W. D. CHESTERMAN. *Oxford University Press* (1951) xiii + 167 *pp.*, 32 *plates.*

This monograph deals with the photographic techniques that may be employed in the study of events which occur in too short a time for them to be observed visually, and discusses the conditions of speed, lighting, repetition and sensitivity which influence their choice. Techniques are described in chapters dealing with intermediate rate (intermittent and continuous film) cameras, film drum cameras, single picture cameras synchronized for flash illuminants, spark and schlieren photography, light sources, choice of sensitive materials. Applications are described in examples from zoological studies, biological and medical sciences, physical and engineering research, and the military field. The extensive bibliography and the 32 plates illustrating the many applications of the photographic technique are valuable features. R. W. FISH